Interior and Exterior Lighting

By

C. E. WEITZ

ILLUMINATING ENGINEER, NATIONAL LAMP WORKS
GENERAL ELECTRIC COMPANY

INTERIOR LIGHTING PRACTICE
Parts 1-2

EXTERIOR LIGHTING PRACTICE

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Note.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

INTERIOR LIGHTING PRACTICE, PART 1

INTERIOR LIGHTING PRACTICE, PART 2

EXTERIOR LIGHTING PRACTICE

INTERIOR LIGHTING PRACTICE

Serial 2718A (PART 1) Edition 1

INTRODUCTION

GENERAL CONSIDERATIONS

1. Electric lighting has become a most important essential of modern life. Not only is it an indispensable utility in commerce and industry, on our streets, and in our homes, but many of our amusements, recreations, and social activities are dependent upon artificial light. Aside from its pure utility, if skilfully handled it becomes one of the most versatile, most compelling, and most appealing mediums in the field of decorative arts.

In the study of modern lighting practice, it is worth while to consider, at the outset, the effect that electric light produces on modern civilization, and to ponder for a moment on what the effect would be if a return were made to the flame sources of 50 years ago. Furthermore, in taking up the subject of modern electric lighting, it is not correct to assume, as formerly, that artificial light is merely a substitute for daylight. While it is true that, from the standpoint of vision, the eyes evolved under daylight standards of illumination may be a hundredfold the intensity of our most liberal systems of artificial lighting, yet the fact remains that in many aspects electric lighting is superior to daylight in the uses to which it can be put.

It is possible to control its intensity, its color, its direction, its distribution, its location, and its steadiness. This may be done at will for any result that pleases our fancy or needs. In this respect new realms of service and value are opened to us far broader than can be covered in detail in this lesson.

The point to remember is that artificial light has many attributes of constancy, quality, and controllability beyond that of daylight. These qualities, which are just now being realized,

make the study of artificial lighting and its adaptation to modern practice a particularly interesting and important one. The electrical industry was developed around the electric light, and, in spite of the remarkable developments in power and heating applications, lighting remains the principal source of revenue for central stations and electrical distributors.

STEADY RISE IN LIGHTING STANDARDS

2. In the early years of electric light, its safety and convenience recommended it as a desirable substitute for older flame sources, and these advantages alone were sufficient to extend its use. Up until the last few years very little studied consideration was given to the manner in which light was being used. However, modern civilization has come to depend more and more upon electric light because of the many improvements in design and efficiency of lamps, and because of the greatly decreased cost, greater dependability, and abundance of electric energy. Some buildings have been designed to the extreme that they admit little or *no daylight, artificial light being substituted.

This tendency to use artificial light has necessitated the most thorough research as regards the relation of lighting to eyesight and vision; it has occasioned detailed study of all phases of lighting economics; and it has directed the design of practical lighting equipment and accessories to meet the demands for refinements in artificial illumination. Our standards of lighting, from the standpoint of both quality of light and the quantity that should be recommended, are gradually being raised to conform to the new visual requirements and new economic conditions.

It is a matter of common knowledge that our eyes see more easily and quickly out of doors in daylight where the illumination intensity may be several thousand foot-candles. Daylight illumination indoors, on the other hand, rarely ever exceeds one

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*Note.—An example of this is the windowless factory building, covering nearly two city blocks, erected in Fitchburg, Mass., for the Simonds Saw and Steel Co. Adequate systems are installed for scientific lighting, ventilation, and noise absorption.

hundred foot-candles, and in most cases this value is obtained only near windows or beneath skylights. Away from the windows the illumination falls off rapidly to very low values. Foot-candle readings taken in a modern factory building with a wall

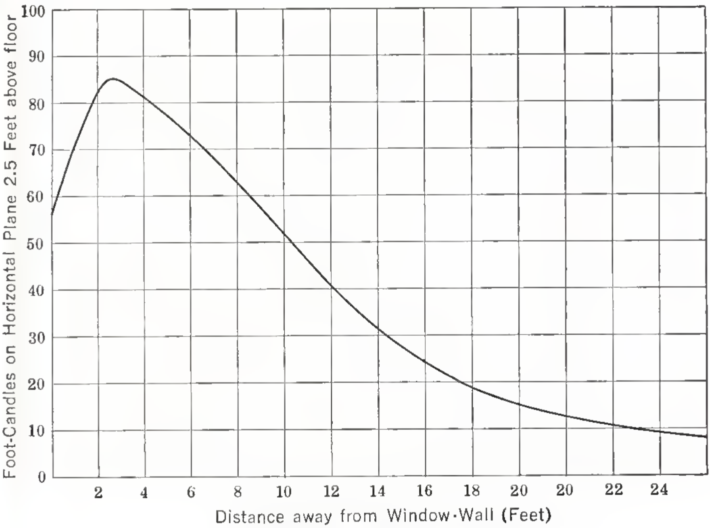


FIG. 1

of ribbed glass showed that on a clear morning less than 5 foot-candles were delivered at the tool point of a shaper 30 feet from the windows. This point is illustrated by the results of tests shown in Fig. 1, where the maximum and minimum illumination values are shown in respect to the distance from the windows. On cloudy days or in early morning or late afternoon hours, much lower values would result.

The inadequacy of daylight illumination indoors for the severe visual tasks of modern industrial and commercial work makes some artificial lighting necessary. Because it is constant in quality and can be supplied in any amount, a good system of electric lighting is more important than extraordinary provision for daylight. As a matter of fact, it has been demonstrated that the increased construction costs, the extra cost for heating, and the cost of cleaning windows and skylights actually make

daylight cost more in the long run than does artificial lighting. This seems logical, since the daylight facilities are useful for only 10 to 12 hours, while the artificial-lighting system will provide illumination of constant quality and quantity, and the investment in electric-lighting facilities is effective throughout the 24-hour period.

KNOWLEDGE OF EYESIGHT AND SEEING INCREASING

3. Without light the best eyes are blind; with but little light our vision is uncertain and objects are seen dimly; with more light, vision is improved, colors are distinguished, and our freedom of action is extended. Every person is dependent on vision to do the daily tasks and to keep safe from accidents. Inadequate light is the primary cause of more than 15 per cent. of the industrial accidents, the cost of which aggregates more than the total factory lighting bill. Spoilage in manufacturing operations, errors in office work, returned goods in stores because of inadequate lighting amount annually to many millions of dollars. All of these factors enter into the economics of lighting and affect the standards of practice in the various fields.

Of even more importance than these factors, which can be computed in dollars and cents, is the effect of poor lighting on eyesight, the most priceless possession of every individual. Since the basic reason for any lighting system is to provide light for seeing, the only adequate system is one that permits reliable and accurate vision without eye discomfort or strain, and most certainly one that safeguards, in every possible way, against aggravating eye defects. It is obvious, therefore, that the study of proper lighting is inseparably involved in the study of eyesight, or what might be called the science of seeing.

In Table I is a summary showing the prevalence of defective vision. The percentages there given were computed with respect to certain groups of persons variously engaged and also with respect to groups of certain ages. While it is impossible to say just what combinations of circumstances have brought about these rather appalling conditions, since light and the eye are so interdependent, it is natural to conclude that the relative low standards of lighting coupled with the severe long-hour use of

the eyes have been major contributing factors. Seeing is a partnership between the eye and illumination. The oculist deals with only one member and endeavors to sharpen vision by the aid of glasses. The other partner, illumination, is entirely within our control and with it the process of seeing can be regulated and influenced.

4. Much has been done to establish the foundation for what has been termed the new science of seeing. In this research work, four fundamental factors of vision have been

TABLE I

PREVALENCE OF DEFECTIVE VISION

By Groups	Per Cent. Defective	Per Cent. Corrected	Per Cent. Uncorrected
Public schools	22	13	9
Colleges	40	18	22
Industries	44	19	25
By Ages			
Under 20	23		
Under 30	39		
Under 40	48		
Under 50	71		
Under 60	82		
Over 60	95		

separated out and studied in exacting detail. These factors are: (1) size of object, (2) brightness, (3) contrast, and (4) time of exposure. Millions of test observations under all manner of illumination conditions have resulted in a better foundation on which to base our lighting recommendations. All of the studies point out the fact that our ability to see accurately and quickly increases as the illumination increases. Almost everyone is willing to grant this as only common sense, yet in practical problems of interior lighting the question of how much light can be profitably provided must be based on reliable data. As higher and higher lighting standards are developed, the question always arises as to the point where the extra cost of addi-

tional light overbalances the benefits from further improved seeing.

Improvements in seeing continue to accrue for illumination levels far beyond our current standards. This is indicated in Fig. 2, where, for example an increase in foot-candles of from 10 to 30 results in a relative improvement of from 114 to 130 in eye benefit. This leads to the conclusion that the future will see much higher illumination standards in common use.

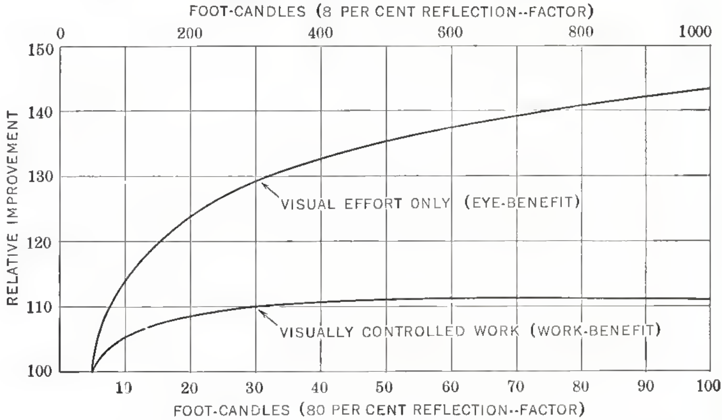


Fig. 2

It will be noted that this chart has two scales of foot-candles; one at the bottom for an 80-per-cent. reflection factor and one at the top for an 8-per-cent. reflection factor. This brings out a very important point, namely, that of the effect of contrast of an object or a detail to be seen, with its background. For example, a certain improvement in seeing is obtained for 30 foot-candles as indicated on the lower scale, where the contrast is black on white. On the other hand, if the contrast is black on a very dark grey, whose reflection factor is only 8 per cent., 300 foot-candles would have to be provided for an equivalent improvement in seeing. That is the reason for providing higher levels of illumination for work on dark goods or materials than when light-colored materials are present. Most visual applications fall in the range between the two extremes shown on the two scales.


10 FOOTCANDLES
ON OBJECT
GLARE
WASTED BY GLARE
DEGREES FROM
LINE OF VISION
40°
20°
53%
10°
69%
5°
84%
DISCOMFORT
FOR EYES
TO BE SEEN

FIG. 3

It should be emphasized here that the amount of illumination is only one phase of seeing. In addition to the effect of contrast already mentioned, bright, glaring light sources within the field of view present a serious handicap. Such sources not only cause discomfort and strain but represent a positive waste. This is illustrated graphically in Fig. 3. Because the pupil of the eye automatically contracts to a small opening when a bright light source is in view, not sufficient seeing light enters the eye to reveal details. *By seeing light is meant the light that falls upon an object to be seen and from which it is reflected to the eye to form the image on the retina.* Since a glaring light is many times more brilliant than a lighted object, its image overpowers all else and vision is difficult. As shown in Fig. 3, when the bright light is within 5 degrees of the direct line of vision, 84 per cent. of the light is wasted. The greater the angle between the light source and the line of vision the less disturbing it is. Wherever bare lamps or other glaring light sources are in evidence, it is a rule, almost without exception, that the illumination could be very much improved.

For purely utilitarian lighting, both the quality and the quantity of the illumination are important, and the lighting specialist must know not only the engineering features of illumination design, but should also understand and appreciate how the eyes use light. In this respect the lighting specialist has the opportunity of really becoming a seeing specialist, and for service in this capacity the world has need.

LIGHT FOR BEAUTY AND DECORATION A NEW FIELD

5. Emphasis has been placed on the steadily rising standards of illumination for better vision, in order to bring out the necessity for considerable foresight in planning installations that are flexible enough to meet the needs of the future. Another point that must be kept in mind is the increasing use, in many types of installations, of lighting facilities that lend decoration and beauty to interiors. In this case, the seeing value of light is of little concern and its function is confined to colorful settings, interesting silhouettes, and luminous patterns. Thus, the field of the lighting engineer is extended into the realm

of art and decoration and into the psychology of color. This field of lighting application possesses great possibilities and involves a great many related subjects, each of which offers many bypaths for study and development.

ADEQUATE WIRING SYSTEM THE BASIS OF GOOD LIGHTING

FACTORS TO BE CONSIDERED

6. General Data.—The general acceptance of modern standards of illumination has brought the question of adequate wiring to the serious attention of the lighting industry and of consumers everywhere. Hundreds of instances have been encountered where owners of buildings desired to increase their illumination to modern economic standards and were unable to do so without expensive alterations in the wiring of the buildings.

So important is the matter of adequate wiring, not only in older buildings but also in new building projects, that it is worth while to discuss in this lesson the general factors which enter into the economics of wiring as related to modern lighting practice. While we can do no more than predict what the requirements will be in the future, the trend in the use of lighting and other electrical devices is upwards. Therefore, in planning for adequate wiring, provision should be made for future increases, which are certain to come.

In older buildings most lighting circuits are already loaded to capacity because of the many electrical conveniences that have been put in use. If attempts are made to improve the lighting by replacing present lamps with lamps of higher wattage, without increasing the size of wire or running additional circuits, excessive voltage drop occurs. Since incandescent lamps are sensitive even to small voltage variations, low operating voltage causes poor efficiency of the lamps. This in turn increases the unit cost of light, as well as produces unsatisfactory lighting service.

There are three things that contribute to undervoltage burning of lamps, each of which requires a different means of

correction: (1) The average voltage delivered by the lighting company to the customer's premises during the lighting hours may be lower than its normal value. This can be corrected only by regulating devices installed on the distribution lines of the central station. (2) The labelled voltage of lamps used may be higher than the nominal circuit voltage. This can be corrected by checking the socket voltage and using lamps of that voltage rating. (3) The amount of voltage drop in the customer's wiring from the meter to the lamp socket may be excessive, causing low-voltage operations of lamps. In this case the wiring is too small for the load, and considerable energy is used in heating the wires instead of going into the lamps to produce light. This condition can be corrected only by interior-wiring alterations.

TABLE II

RELATION BETWEEN ILLUMINATION AND UNDERVOLTAGE BURNING

Volts Delivered at the Socket in Per Cent. of Labelled Lamp Voltage	Per Cent. of Normal Light Output	Per Cent. of Normal Watts
100	100	100
95	84	92
90	70	85
85	57	78
80	45	71

7. Undervoltage Burning and Illumination.—The light output (the lumens delivered by the lamps on the job) decreases much more rapidly than the voltage. The voltage actually delivered at the sockets should be known and carefully considered in every carefully worked out lighting problem. No important wiring job ought to be installed without a voltage check. The customer receives less light from his lamps when the voltage is low, as shown by Table II.

It is evident from Table II that a 100-watt lamp burning 15 per cent. undervoltage (85 volts) will produce only 57 per cent. of normal light output, while consuming 78 per cent. of the normal watts.

Let it be considered for a moment just what happens to the watts consumed and the light produced by an incandescent lamp when it is operated 10 per cent. undervoltage, for example. If this undervoltage burning is due to low supply voltage, the wattage is reduced, say, 13 per cent., while the light is reduced 26 per cent.; moreover, the light will be of a yellower color. If the interior-wiring drop is entirely responsible for the undervoltage burning, the wattage at the meter is reduced only 5 per cent., approximately. In this case, for an additional expenditure of 5 per cent. in wattage, as recorded at the meter, an increase in light output five or six times as great as the increase in wattage would be obtained, and the light thus secured would also be of a very good color quality.

TABLE III

RELATION BETWEEN LUMEN COST AND UNDERVOLTAGE BURNING

Average Voltage at the Socket in Per Cent. of Labelled Lamp Voltage	Cost per Lumen, in Per Cent. of Cost when Operated at Labelled Volts
100	100
95	107
90	118
85	134
80	156

8. **Undervoltage Burning and the Unit Cost of Light.**—If, now, the cost of operating the lighting installation is compared with what the customer receives for his money, that is, if the cost per lumen is figured, the unit costs mentioned in Table III are obtained.

The unit cost of light rises as the voltage drops below its normal value, so that it certainly is not to the customer's advantage to operate lamps undervoltage. As a matter of fact, for conditions represented by the previous calculations, and typical of those applying to many commercial and small industrial users, the customer should operate his lamps overvoltage by about 7 per cent. to obtain the lowest unit cost of light (about 4.5 per cent. less than at normal voltage).

The cost of the electricity lost in the customer's wiring is borne by the customer himself. If a skimpy wiring job is installed in order to cut down the cost of wiring the premises,

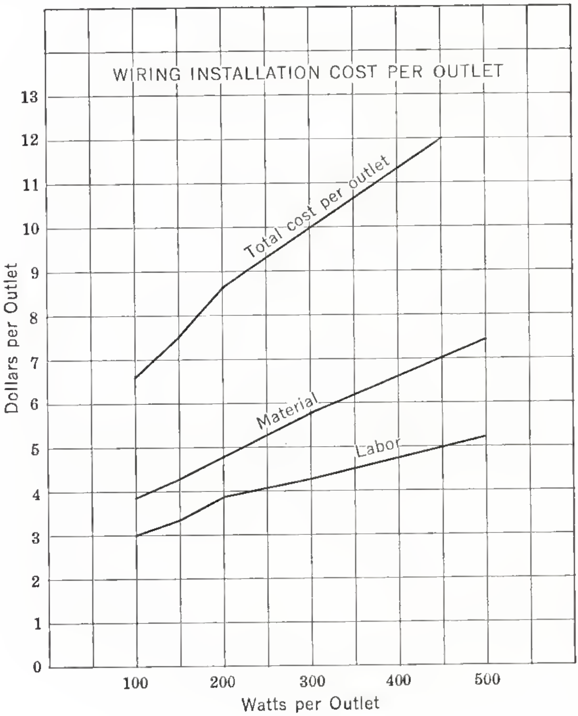


FIG. 4

an appreciable part of the electricity paid for by the customer is wasted owing to the inadequate wiring; in a few years this loss may easily wipe out the initial saving. The wiring capacity of a circuit may be adequate from the standpoint of safety to life and property and still be inadequate from the standpoint of the economic distribution of energy. A pair of No. 14 wires can carry 15 amperes safely without overheating, but they cannot carry this current to a load more than 25 feet away with a drop of not more than 2 volts. To carry 15 amperes to a load 100 feet away, without more than a 2-volt drop requires the use of a pair of No. 8 wires. Often considerable improvement will

result from increasing the current-carrying capacity of badly overloaded feeders, even where branch circuits cannot be rewired.

9. Adequate Wiring Most Economical.—In the long run, wiring installations that provide for future increases in the lighting load not only save expensive alterations and extensions, but also deliver energy to the sockets without excessive voltage losses. In many cases the actual increased cost for larger feed-

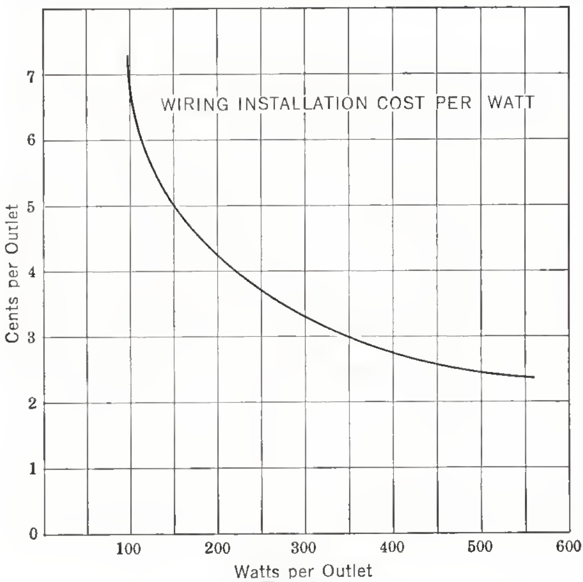


FIG. 5

ers and branch circuit wiring is almost negligible, since the labor for installing and the cost of the material are not increased in proportion to the added capacity.

In Fig. 4 is shown the average of a number of contractors' estimates on the added cost for providing additional wiring capacity over what might be required to meet present needs. Such cost estimates vary somewhat according to the particular locality and contractor. The data in Fig. 4 indicates that installing wiring sufficient for 200 watts per outlet instead of 100 watts per outlet only increases the total cost per outlet from approxi-

mately \$6.75 to \$8.60. Roughly, according to cost records, wiring for double the capacity may be installed originally at only about a 30-per-cent. increase in cost. The increase in the wiring-installation cost per watt for an increase in the watts per outlet is shown in Fig. 5. Such an illustration shows clearly that the wiring-installation cost per watt decreases quite rapidly as the watts per outlet increase.

It has been pointed out that poor wiring causes undervoltage operation of lamps and unsatisfactory lighting service. It is not generally appreciated by those who have poor wiring just how this affects costs. For example, if a wiring system were installed on the basis of 150 watts per outlet, and later on, because of additional illumination requirements, 300-watt lamps were used, the voltage drop would be doubled. This would mean low efficiency and loss of light from the 300-watt lamps. This loss over a period of 2 years would more than equal the cost for good wiring, had the required additional capacity been installed initially. Thus, in the usual case, one pays for a good wiring job whether he has it or not. If it is found necessary to rewire a building to provide for additional capacity, the cost for the alterations will be found to run three or four times the amount of the increment cost for the job done initially. Reserve capacity in wiring does not put any burden of use on lighting customers, but merely represents the facility for additional service when needed.

SPECIFICATIONS FOR WIRING OF LIGHTING CIRCUITS

INTRODUCTION

10. Electrical Codes.—Most wiring has been specified on the basis of complying with the requirements of the National Electrical Code or supplementary local municipal ordinances, and there seems to be a mistaken impression that such specifications denote adequate wiring. Actually, the electrical codes have for their purpose the safety of the installation, and even though the installation may be safe from the fire underwriter's standpoint, still the system may be woefully inefficient and inadequate for good lighting service.

In order to suggest adequate wiring standards to meet the requirements of the present and the near future as far as lighting is concerned, the following data have been issued by the National Electric Light Association. Such data are prepared in specification form for the convenience of the architect and the electrical contractor.

11. General.—The following specification, Arts. 11 to 25, define the minimum limits of wiring installations for lighting and other applications of electricity commonly supplied from so-called lighting circuits that will provide adequate carrying capacity and reasonably low voltage drop. This specification applies only to installations for connection to 115-volt or 115-230-volt distribution systems and does not apply to wiring for the supply of energy to power equipment.

This specification is based upon 15-ampere fusing of branch circuits. If local regulations limit the load on branch circuits to less than 15 amperes, the wattage and area limits herein specified should be proportionately reduced.

As the requirements given herein are minimum, it is recommended that the installation be increased and elaborated upon in proportion to the design, scale, and appointment of the structure.

REQUIREMENTS FOR ALL COMMERCIAL AND PUBLIC STRUCTURES

12. Classification of Structures.—This specification applies to the wiring installations of all buildings except structures specifically designated for occupancy as dwellings, apartments, industrial plants and structures with interiors requiring special consideration and treatment, such as theaters, large auditoriums, banking rooms, etc.

13. Convenience Outlets and Circuits Therefor.—Convenience outlets shall not be placed on the same circuit with outlets for general illumination. No more than ten convenience outlets shall be placed in one circuit (in barber shops, dentists' and doctors' offices, beauty parlors and similar places, not more than two per circuit) and those located in the wall or baseboard shall be of the duplex type. No wire smaller than No. 12 shall be

used for convenience-outlet circuits. Runs exceeding 100 feet from panel board to the first outlet should be avoided wherever practicable by relocation or addition of panel boards. Where such runs are not avoidable, no smaller than *No. 10 shall be used from the panel board to the first outlet and no smaller than No. 12 between outlets.

14. Ceiling Outlets for General Lighting.—Whenever possible, outlets should be located on squares. In offices and schoolrooms, no two adjacent outlets shall be spaced farther apart than the distance from floor to ceiling. In other interiors, the space may be extended to $1\frac{1}{4}$ times the ceiling height. In hallways and corridors, maximum spacing between outlets shall not exceed 20 feet.

TABLE IV

AREAS FOR LIGHTING CIRCUITS FOR SPECIAL CASES

Rooms, or Areas, to Be Lighted	Area for Each Circuit Square Feet
Auditoriums	600
Drafting rooms	200
School drawing and art rooms	200
School corridors and stairs	600
General lighting from other than ceiling units	200
Hospital wards and private rooms	600
Hospital laboratories and rooms for sterilization of instruments	200
Hospital operating rooms	400, plus three circuits
Garage driveways and ramps	1,000
Garage wash racks	One additional circuit from panel board to the wash rack for special illumination

15. Area for Branch Circuit for General Lighting.—Except as specified in Table IV, there shall be one branch circuit for the general lighting for each 400 square feet or less of working space or rentable area, and one branch circuit for general light-

*Note.—In so far as No. 10 wire cannot be properly connected on the binding screws of the convenience-outlet device, it is suggested that No. 12 circuit wire be spliced on to No. 10 for such device connection.

ing for each 800 square feet of hallways or passageway or other non-rentable or non-producing area.

16. Wattage per Branch Circuit for General Lighting.—If the wattage of outlets is specified on the plan, branch circuits shall be so arranged that, based on such specified wattage, the initial load on any circuit shall not exceed 1,000 watts, except in the case of a single lamp of larger size. This is supplementary to the requirements of Art. 14.

17. Wire Size of Branch Circuits for General Lighting. No wire smaller than No. 12 shall be used in branch circuits. For runs of over 50 feet from the panel board to the first outlet, no wire smaller than No. 10 shall be used, and no wire smaller than No. 12 between outlets.

Runs exceeding 100 feet from the panel board to the first outlet shall be avoided wherever practicable by relocation or addition of panel boards. Where such runs cannot be avoided, the areas specified in Art. 15 shall be reduced by 40 per cent. and the initial load on any circuit shall not exceed 600 watts.

18. Panel Boards.—Panel boards shall contain a minimum of one spare circuit position for each five circuits in service or fraction thereof.

It is recommended, but not required, that each circuit on panel boards be supplied with a switch in addition to the fuses, or with a circuit-breaker, except that individual circuit switches or circuit-breakers are not needed for circuits supplying show windows and signs controlled by time switches.

19. Service and Feeders.—The current-carrying capacity of the service and feeders shall be great enough to supply 7.5 amperes to every 15-ampere branch circuit position provided for on the panel board or panel boards which they feed, except as permitted in the third paragraph of this Article, in addition to any power requirements for heavy duty appliances or other non-lighting equipment which may be supplied through this service and for feeders.

The service and feeders shall be of such size that the total voltage drop from the service entrance to the panel board will

not exceed 2 per cent. with a load equal to the total capacity as stated in the preceding paragraph.

For buildings in which the floor area exceeds 10,000 sq. ft., the standard demand factors of the National Electrical Code may be applied in determining the service and feeder carrying capacities and voltage drops. Such demand factors, when used, shall be applied only to the loads from the 15-ampere branch circuits, computed according to the first paragraph of this section.

Conduits and ducts for enclosing service and feeders shall be of sufficient size to permit replacing the original service and feeders with wires two standard gauge sizes larger, or 50 per cent. greater in capacity. Where conduits or ducts are not used, the original installation should have this excess capacity.

ADDITIONAL REQUIREMENTS FOR STORE AND OFFICE BUILDINGS

20. Store Buildings—Show Windows. — At least one branch circuit shall be provided for each 5 linear feet or major fraction thereof of plate glass, measured horizontally, for general illumination of the window.

At least one convenience outlet shall be provided for each 5 linear feet or major fraction thereof of plate glass, measured horizontally, for window spots or flood lights. These convenience outlets shall be on separate circuits with not more than three outlets per circuit. Such circuits shall be controlled independently of those for general illumination of the window.

In or near the floor of each window, there shall be at least one convenience outlet for each 50 square feet or major fraction thereof of floor or platform area. In no case shall there be less than one for each 10 linear feet of plate glass. No more than six such outlets shall be placed on a circuit.

21. Store Buildings — Exterior Electric Signs.—Where there is a rigid conduit not smaller than 1 inch trade size or an equivalent duct or where conduit or duct is not used, three No. 6 wires shall be run to the front face of the building, preferably from the panel board, and shall have at least four branch circuit positions or their equivalent for supplying an electric sign.

22. Store Buildings. — Convenience Outlets.—In stores having supporting columns, there shall be installed at least one convenience outlet on or in each of the supporting columns, for decorative lighting, electrically-operated equipment or display fixtures.

In stores having no supporting columns, there shall be installed at least one floor convenience outlet for each 400 square feet or major fraction thereof of floor space, these outlets to be uniformly distributed over the entire area. In any display area, no more than six such outlets shall be connected to a circuit.

23. Store Buildings—Provisions for Show-Case Lighting. There shall be one circuit terminating in a pull box for each 40 linear feet or major fraction thereof of actual or probable show-case and wall-case frontage together, or wall-case frontage alone.

If the location of show- and wall-cases together or wall cases alone has been definitely determined before the wiring is done, and the original wiring layout provides capacities and facilities for show- and wall-case lighting which are equal to, or in excess of, the minimum just stated, then such wiring will be acceptable.

24. Office Buildings.—Convenience Outlets.—There shall be a branch circuit to supply convenience outlets for every 800 square feet of floor space or major fraction thereof.

In each separate office room with 400 square feet or less of floor area, there shall be installed at least one convenience outlet for each 20 linear feet of wall or major fraction thereof.

In each separate office room with more than 400 square feet of floor area, there shall be installed at least four convenience outlets for the first 400 square feet of floor area and at least two additional convenience outlets for each additional 400 square feet or major fraction thereof.

Outlets should be placed at suitable locations to serve all parts of the office room.

THE LIGHTING FIELDS

CLASSIFICATIONS

25. Definitions.—Although artificial light is used in every conceivable type of building and for all manner of service, it is customary to think of the various applications as falling into several general classifications:

(*a*) *Industrial lighting,* which comprises factories, mills, warehouses, and the great variety of workshops where any kind of industrial work is carried on.

(*b*) *Commercial lighting,* whose class of application includes the store and show window, display cases, office and drafting room, school and classroom lighting, and lighting for indoor recreations.

(*c*) *Residential lighting,* comprising all of the wired homes of the country. This is the largest single field from the standpoint of number of customers on the central station lines.

(*d*) *Public building lighting,* referring to the lighting of churches, hospitals, armories, auditoriums, museums, and theaters, and to the more unusual buildings where the lighting must be adapted to unusual treatment to conform to architectural planning or special lighting requirements.

INDUSTRIAL LIGHTING

26. General Discussion.—Lighting for the factory and workshop should be regarded as a tool of production rather than as an overhead expense. As such it should pay its own way on the same basis as any investment in automatic machinery, labor-saving devices, or hygienic equipment. It has been demonstrated many times in industrial work that good lighting can aid production, cut down spoilage of materials, and prevent accidents, and withal make the usual factory a more cheerful and more pleasant place in which to work. The result has been a gradual improvement in factory lighting.

The right-hand half of the installation shown in Fig. 6 illustrates how modern lighting may transform dingy, gloomy factories, as indicated by the left-hand half of Fig. 6, into bright work places and suggests all of the attendant advantages previously mentioned.

As a tool of production in industry, lighting must be efficient and without frills, and here, particularly, what has been said about the relations of light to vision is of greatest significance. The recommendations of modern factory-lighting practice which follow, have for their background the scientific studies that have been made.

27. General Overhead Lighting Required. — The basic requirement for good factory lighting is an orderly arrangement of overhead lighting units to produce illumination that is uniformly and evenly distributed throughout the room. This allows every part of the factory to be available for productive work without the dark corners or the severe contrasts in intensity which result from individual lights placed at each machine or work position.

Where general lighting is installed overhead, lamps fewer in number but of higher wattage may be employed, making possible greater efficiency of the system. For example, one 150-watt lamp produces approximately as much light as ten 25-watt lamps; a single 1,000-watt lamp produces double the light of twenty 50-watt lamps. It is therefore best to design the general lighting so as to make use of higher wattage lamps, not alone because of their greater efficiency, but also because fewer units will be necessary to install and maintain. Local bench or machine lights are, in most cases, unnecessary, where well-planned general lighting exists. This obviates the nuisance of lamps on drop cords, with their usual difficulty of adjustment, lamp theft, and probable glare.

28. Amount of Light Required.—The more experienced the illuminating engineer, the less he feels inclined to give specific figures as to how much light any factory operation requires. Such an engineer has no hesitancy, however, in stating that more light than is generally used today can be used economically and

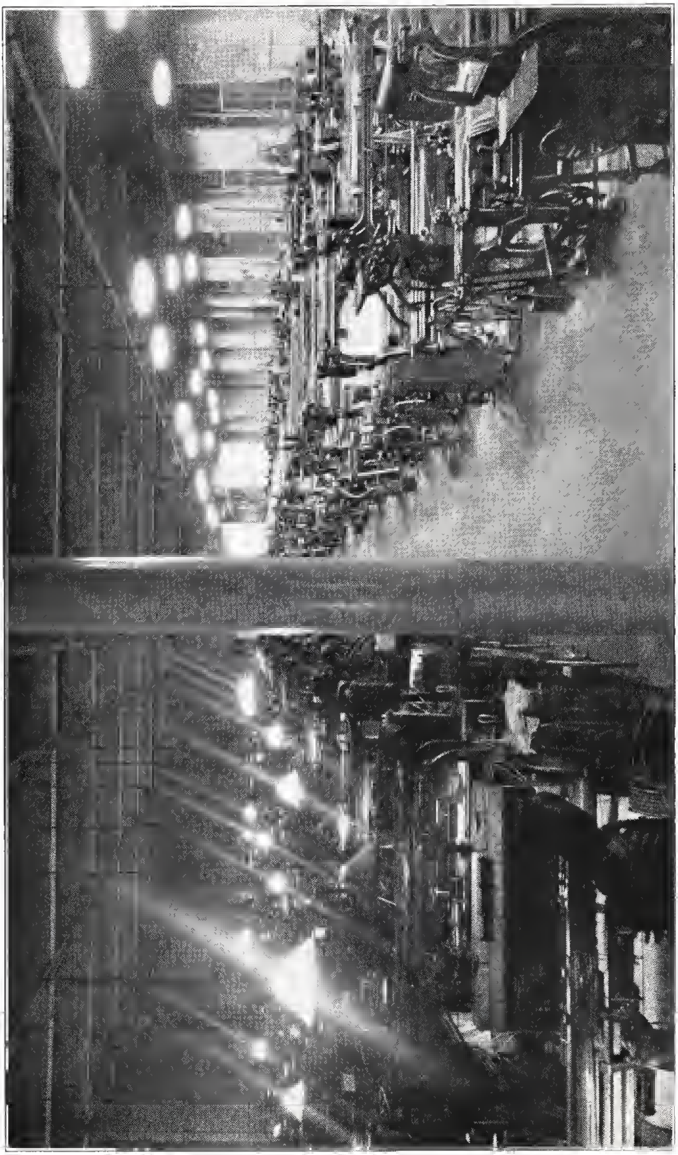


FIG. 6

profitably. Reeent years have seen a large number of faetory lighting installations with eapacities of five and six times as mueh light as would have been eonsidered neeessary 10 years ago.

There are five general levels of illumination, as indicated in Table V, whieh the designer of a lighting system will do well to keep in mind.

TABLE V

LEVELS OF ILLUMINATION

5-10 foot-candles	Satisfactory for work of a coarser nature, such as rough assembling, rough packing, coal and ash handling, and the like, where the eyes are not called upon to see small details quickly and accurately. This value also would represent an abundance of light for warehouses, stock-rooms, and aisles and passageways which are always kept free from obstructions. Enough light to dispel any sense of gloom.
10-15 foot-candles	Considered good lighting for most kinds of work on light-colored surfaces, and for fairly close work on dark surfaces. Not enough light for examining fine details on dark fabrics or materials.
15-25 foot-candles	A good modern standard of lighting. In addition to permitting quick and accurate execution of all work except the most exacting, lighting of this kind stimulates the workman and makes for fast and accurate production.
25-50 foot-candles	Examples of general lighting of this order are now not unusual. Provides a margin of safety that conserves ocular and nervous energy over and above the simple requirements of vision. These high levels of general illumination are often installed to avoid all use of local lighting units.
50-100 foot-candles	The upper range of artificial lighting values as judged by present experience. Necessary in extremely fine, accurate operations and in inspections of very minute details. Usually employed locally and supplemented by general lighting of lower value.

29. Spacing of Units Most Important.—In planning factory lighting the correct location of outlets is most important. The relations of the spacing and mounting height of units are covered in certain Tables in the lesson on *Illumination Principles*, together with the essential technical data on the design of general lighting for all classes of interiors. These principles should be studied carefully and mastered.

Many installations are made with too few outlets to give uniform lighting, and in these cases the only alternative is to add outlets later on, which entails considerable expense above that required to provide these outlets originally.

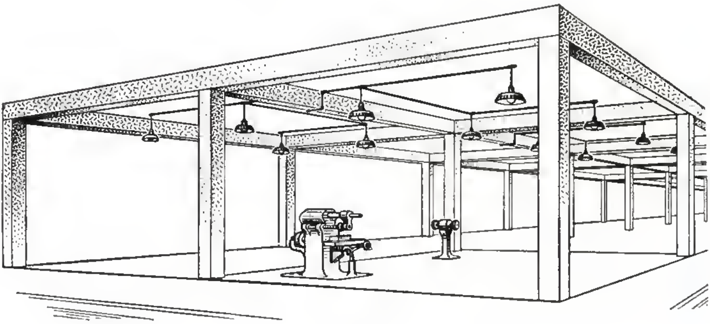


FIG. 7

A simple rule to remember is that in rooms of ordinary ceiling height up to 15 feet, the outlets should be spaced no farther apart than the ceiling height.

30. Units Usually Located According to Bays.—Most factory interiors are usually divided into sections or bays by columns or truss members. It is the usual practice to locate the lighting outlets symmetrically with respect to these bays as indicated in Fig. 7. This makes an installation of good appearance, and at the same time allows bays to be partitioned off into separate rooms, for tool rooms, stock rooms, offices, etc., without further changes in the lighting.

Sometimes where no structural features suggest a natural division into bays, it is necessary in planning the layout to sketch the floor plan and to draw in imaginary bays of uniform size,

the size depending on the grouping of machines, benches, etc. These bays should be chosen as nearly square as practicable.

In the interior shown in Fig. 7, beams divide the interior into 20′×20′ bays with four units symmetrically spaced in each bay. In every case, however, the actual location of outlets will be affected by the location of steam pipes, sprinkler heads, line shafting, and other possible obstructions.

Effective illumination is obtained only by the use of suitable reflectors. Their use is twofold: first, to direct the light downwards efficiently on the work; second, to diffuse the light and protect the eyes from glare. Reflectors of each size are designed to take lamps of certain size and each reflector should be stenciled to show the lamp wattage for which it is designed.

(a)

(b)

FIG. 8

To meet the requirements of the large majority of factories, reflector and lamp manufacturers have made available reflecting equipment of standard design and standard performance. These units are described briefly in the following articles.

31. The RLM Standard Dome.—The use of a standardized enameled-steel reflector, called the RLM Standard Dome, Fig. 8 (*a*), meets all requirements for efficiently directing the light downwards on the work. The light through a bulb, with a white enameled bowl is much softer than that from a clear-bulb lamp, and the white-bowl lamp is therefore recommended for general use with the RLM Standard Dome.

The RLM reflector is made in the following sizes to accommodate the various sizes of lamps.

12-inch diameter	60-100-watt lamp
14-inch diameter	150-watt lamp
16-inch diameter	200-watt lamp
18-inch diameter	300-500-watt lamp
20-inch diameter	750-1,500-watt lamp

32. The Glassteel Diffuser.—Light of much softer quality is obtained by the use of the Glassteel Diffuser unit, Fig. 8 (*b*), than is possible with the other reflector mentioned. It is composed of two parts; first, an enlarged enameled-steel reflector to direct the light downwards; and second, an enclosing opal-glass globe that fits under the steel reflector. This enclosing opal globe provides an enlarged light-source area, thereby greatly diffusing the light and softening the shadows. Perforations in the top of the steel reflector allow a small amount of light to travel upwards, illuminating the ceiling, belts, and shafting, etc. This unit has been widely adopted as the standard for the better class of industrial lighting installations.

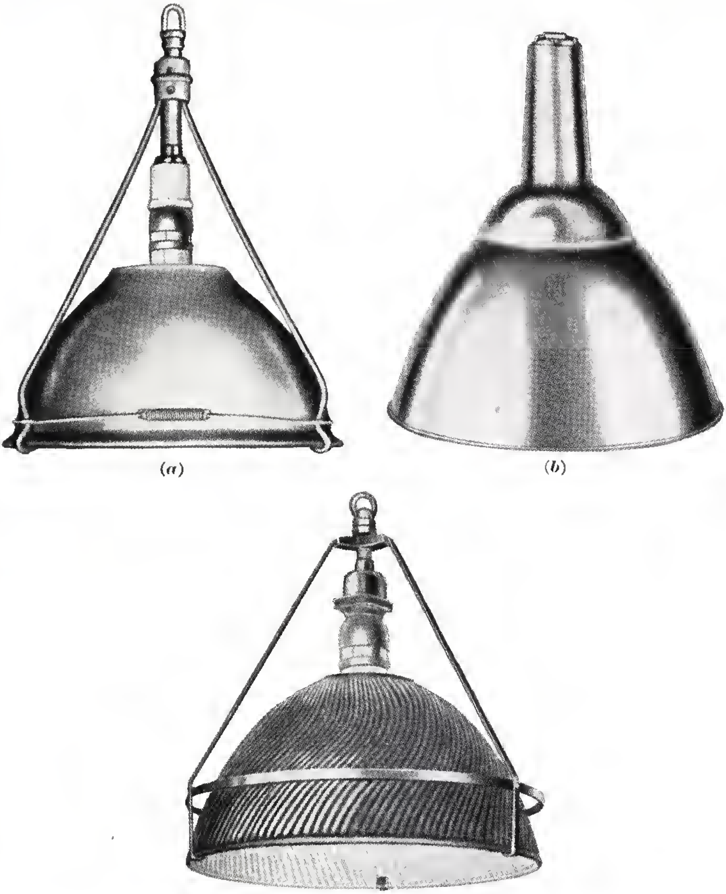
The Glassteel Diffuser is made in three sizes for different sizes of lamps:

18-inch reflector	150-200-watt lamp
20-inch reflector	300-500-watt lamp
24-inch reflector	750-1,500-watt lamp

Considerable advantage in flexibility is gained by the use of the Glassteel Unit. For example, the 20-inch unit is designed to accommodate the 300- and 500-watt clear lamps and will efficiently take 150- and 200-watt lamps with a socket adapter. If this size is chosen, it is possible to change the illumination as desired simply by a change of lamp size, provided, of course, the wiring is adequate for the higher wattage lamps.

33. The Mercury-Vapor Lamp for Industrial Lighting. The mercury-vapor lamp, commonly known as the Cooper-Hewitt lamp, has found considerable application in certain industrial plants, such as metal work or printing plants, textile mills, and places where need for color identification is not a factor.

The direct-current lamp, which consumes 385 watts, and the alternating-current lamp, which consumes 450 watts, are both adapted to general industrial lighting. These lamps are efficient, with a reflector as an integral part of the unit. Because



(*a*) (*b*) (*c*)

FIG. 9

the light is emitted through the 50-inch length of tubing, it is of relatively low brightness and fairly well diffused. The light is identified by the peculiar yellowish-green color due to the several spectral bands of which it is composed. There is a lack of red

rays, with the result that the color of materials viewed under this light is distorted from the natural appearance.

34. Equipment for Craneways and Other High Mounting. The most effective distribution of light in high bays differs slightly from that given by the RLM Dome and Glassteel Diffuser. Because of the relatively greater height of the building in proportion to its width, a concentrated distribution is more effective,

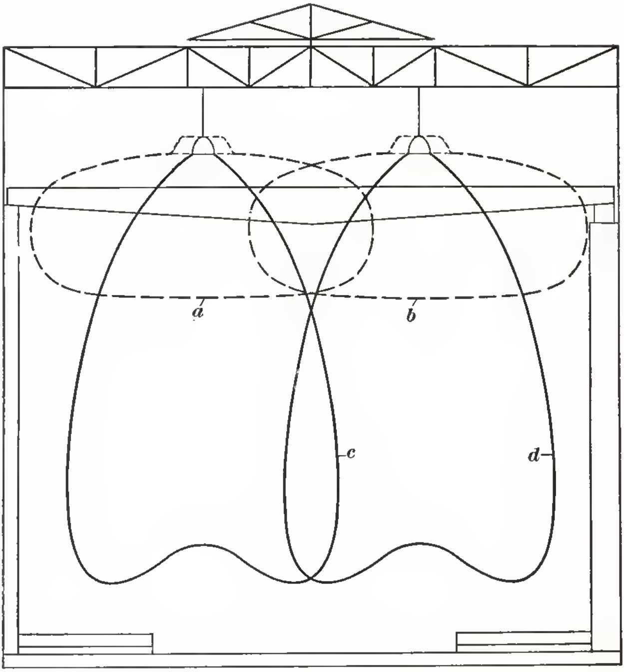


FIG. 10

since it avoids undue waste of light on the sidewalls. For this reason there have been placed on the market units such as are shown in Fig. 9 (*a*), (*b*), and (*c*), which may be called High Bay units and which direct the light in a narrow zone, with consequent greater overall efficiency than if mounted at a sufficient height to clear the crane. A prismatic glass reflector is indicated in view (*a*), an oxidized aluminum reflector in view (*b*),

and a mirrored glass reflector in view (*c*). The crane, as it travels along, will cut off the light from units directly above. This seriously impairs the illumination, particularly where the units are very far apart. To avoid this condition, it is often the practice to install additional units on the bottom of the crane; from the illumination standpoint this is fairly satisfactory when the units are mounted on the crane in such a manner as to avoid severe vibration and shocks to guard against excessive lamp failures. A good solution of the problem is to stagger the units overhead, in which case the crane will not cut off the light from more than one unit at a time.

Although angle reflectors have had wide acceptance for this purpose, it is only in very narrow craneways that angle reflectors used alone are satisfactory, and even then it is best to supplement them with overhead lighting units. Angle units have their widest use in building up illumination on vertical surfaces, over and above that provided by the general lighting system.

In Fig. 10, the outlines *a* and *b* indicate a typical distribution of light from an RLM reflector, while the outlines *c* and *d* indicate typical distribution of light from High Bay units.

35. Foot-Candles in Service.—The foot-candles obtained in service, with the lamp sizes as indicated and spaced according to the data given, are shown in Table VI.

36. Location of Outlets With Respect to Machine Arrangement.—In certain industries, notably textile mills, paper making, printing plants, the machine layout is usually fitted to standard bays. These industries involve long rows of machines, oftentimes quite high, with work aisles between rows of machines. The lighting of work of this character requires that the units be located over work aisles with definite consideration for effective direction of the light on the work and for the avoidance of shadows. Where lighting units are located with respect to the arrangement of machines on the floor, this method is known as group lighting. However, since the machine grouping itself is usually arranged with respect to bays, the group system of lighting may oftentimes be identical with the usual

symmetrical layout. An example of group lighting is shown in Fig. 11.

37. Auxiliary Lighting for Work Benches.—In general, where more lighting units are employed than one per bay, bench lighting can be adequately cared for by shifting the outside rows of units in the general system nearer to the walls along which the benches are placed. This means, of course, that the spacing distance between the outside row of units and the next is greater than it should be, and the illumination at points between the two rows is correspondingly reduced. However, since this area of reduced illumination covers the aisle between the benches and the first row of machines, the effect is usually not serious. On the other hand, where bays are large and only one unit is employed in each bay, the best practice usually requires auxiliary bench-lighting units. A typical good arrangement of auxiliary units is shown in Fig. 12.

The use of 200-watt RLM reflectors, spaced 8 feet apart and mounted 6 to 8 feet above the bench tops, will provide an

TABLE VI

FOOT-CANDLES IN SERVICE WITH LAMP SIZE AS INDICATED

Mounting Height of Units Feet	Approximate Spacing Feet	Approximate Square Feet Per Outlet	Lamp Watts			
			500	750	1,000	1,500
			Foot-Candles in Service			
20-30	15×15	225	16	26	12.7	18
20-30	15×20	300	12	10	27	42
31-36	20×20	400	8.5	13	18	29
31-36	20×30	600	5.5	8.5	12	19
31-36	30×30	900	3.5	6	8	13
31-36	30×40	1,200	3	4.5	6	10
37-50	30×30	900	3.5	5	7.5	11.5
37-50	30×40	1,200	2.5	4	5.5	8.5

NOTE.—It is true that, as the mounting height of units is increased, the farther apart they may be placed and still furnish a uniform level of illumination. However, where the area per outlet greatly exceeds 1,000 square feet, even the 1,500-watt lamps are inadequate to provide the foot-candles of illumination recommended for modern practice.

Fig. 11

average illumination on the bench of about 15 foot-candles; this is in addition to the light received from the general overhead system.

The distance between the units and the wall is governed by the width of the benches. The units should be so located that

Fig. 12

the lamp is out from a wall a distance about equal to the width of the bench.

38. High-Intensity Lighting Methods.—As suggested previously, foot-candle standards upwards of 100 foot-candles are required for certain accurate work such as sewing on dark fabrics, fine inspection, and grading. An example of supplemen-

tary local lighting in a factory is indicated in Fig. 13, where 25- or 50-watt auxiliary lamps in a small deep bowl reflector on an adjustable arm are used. With general illumination from an overhead system providing 10 to 15 foot-candles, this supplementary lighting is used to produce illumination on the work of the order of 50 to 100 foot-candles. The general illumination relieves the severe contrast and avoids eye fatigue that would result if only the local lamps were used.

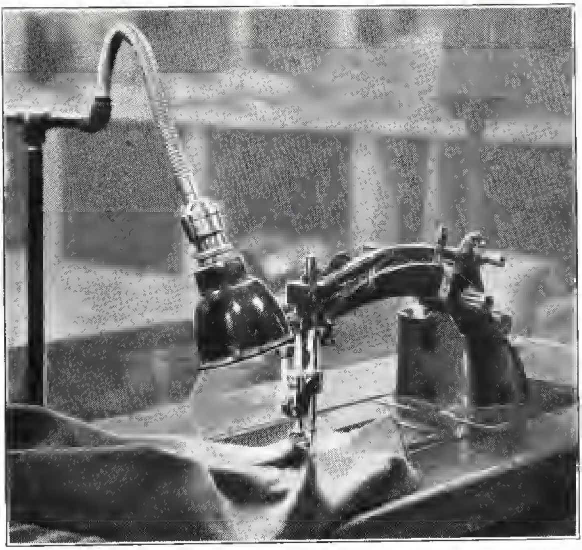


Fig. 13

Another example of a method of supplementary lighting of machines, used extensively in automobile body plants and railroad roundhouses, is the use of auxiliary projectors mounted on the ceiling or on columns. Such an installation for a locomotive roundhouse is shown in Fig. 14. Roundhouse dust-tight projectors each equipped with a 300-watt or a 500-watt clear mazda lamp are shown at *a*. The center of the beam is to be directed toward the bottom of the drivers on the locomotives. Dust-tight porcelain enameled-steel angle-type reflectors each equipped with a 200-watt clear mazda lamp are shown at *b*.

However, where general work such as fine inspection and grading is carried on over a considerable area, general illumination of a high standard may be most satisfactory and economical. An example of such an installation is shown in Fig. 15, where 500-watt daylight units spaced only 4 feet apart provide over 150 foot-candles on the inspection and grading tables.

39. Color-Identification Equipment.—Equipment employing accurate color filters (blue glass coverplates by means of which excess red rays are absorbed so that the transmitted light

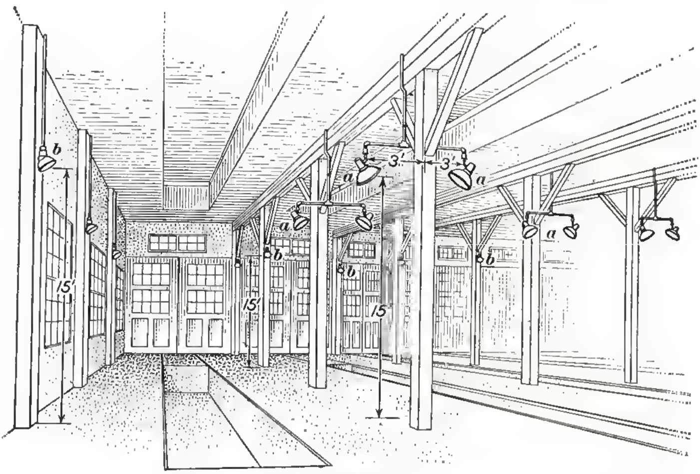


Fig. 14

actually duplicates daylight quality) are necessary where precision in color identification, grading, or other color inspection is required. Color factories, paint and dye mixing, chemical analysis, textile and cigar sorting and grading, lithographing processes, and color printing are examples of industries where color-correcting equipment is desirable. The type of daylight reproducing units employed depends on the specific requirements of the installation.

An example of the use of accurate color-identification units is shown in Fig. 16. This is an installation of 500-watt lamps in concentrating metal-type reflectors with blue daylight glass

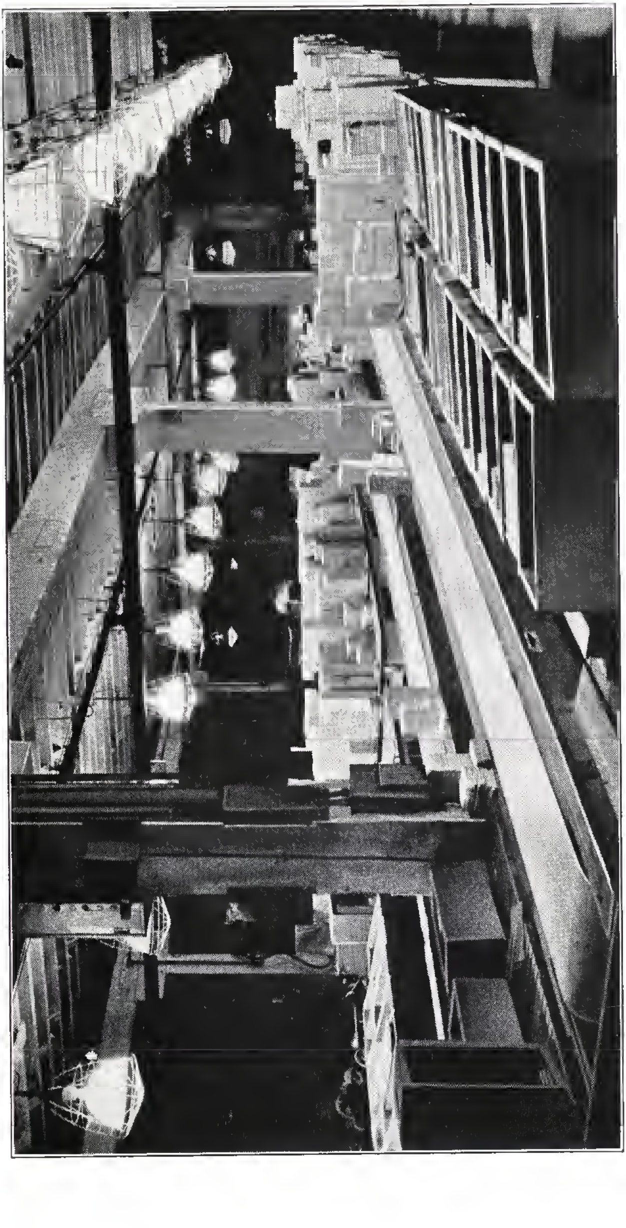


Fig. 15

Fig. 16

coverplates, used in tobacco grading where the leaves are sorted and graded for quality according to precise color standards.

40. Special-Purpose Enclosing Units.—Certain types of industrial applications require, either for safety precautions or for maintenance reasons, special units of vapor-proof or dust-tight construction. Typical units of this character are illustrated in Fig. 17 (*a*), (*b*), and (*c*). All of these types effec-

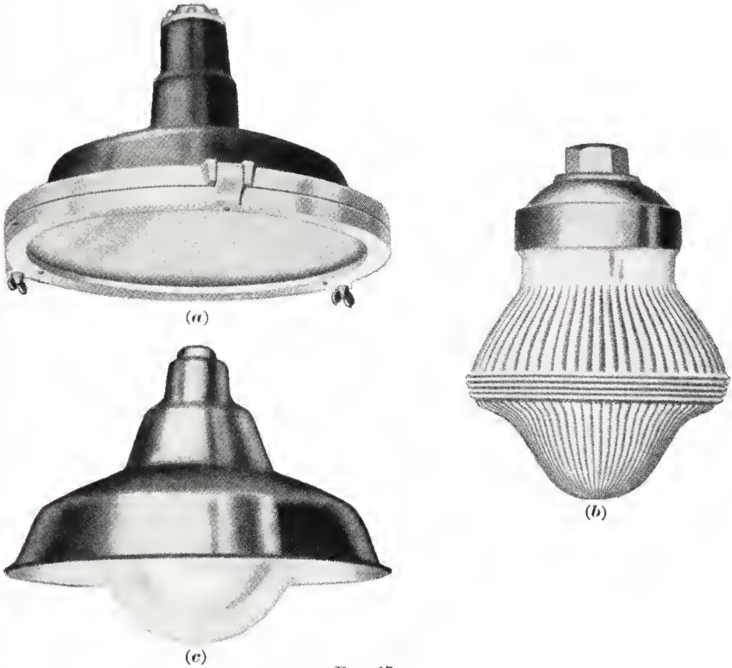


Fig. 17

tively protect the lamp, reflecting surfaces, and electrical connections from dust, dirt, and fumes, facilitating cleaning and preventing deterioration.

In damp places and moisture-laden atmospheres, such as are found in refrigeration plants, engine rooms, shower baths, pickling departments, and the like; also, where the gas and vapor of such processes as electrotyping, oil refining, varnish making, acid making, and the like are present, the corrosive action of

moisture, gas, and vapor upon the reflectors, sockets, and other parts of the equipment make it advisable that equipments in such places be *vapor-proof*.

Dust-tight luminaires are necessary, first, in classes of establishments such as grain elevators, rubber-working plants, spice, flour, and feed mills, and in plants in which powdered sugar, cornstarch, sulphur, and aluminum are used or manufactured. The dust from these processes, hanging finely suspended in the atmosphere, forms a combination that is highly explosive and, although tests show that the ignition temperature of such atmosphere is usually higher than the operating temperature of a lamp bulb, as a safeguard in case of accidental breakage of the bulb, dust-proof units are recommended for these locations.

Second, in dusty, smoky atmospheres, such as railroad roundhouses, foundries, coal and ash-handling sheds, cement mills, and similar places, dust-tight units are often desirable from the standpoint of ease of maintentance.

41. Maintenance.—A lighting system will depreciate rapidly unless kept clean by periodic washing and replacing of burned-out lamps. All lighting equipment should be cleaned frequently. In order to make cleaning easier, disconnecting hangers or special receptacle plugs may be used, particularly where the units are not easily and safely accessible. Where conditions of severe vibration are encountered, special adapters to reduce vibration of the lamp or flexible hangers with shock-absorbing features are recommended.

COMMERCIAL LIGHTING

42. General Discussion.—The broad classification included in the definition for commercial lighting covers many and sundry types of lighting applications, although the general lighting requirements for stores, offices, and schools constitute the principal market for lighting and electrical energy in this field. The general design procedure for such installations follows the same general lines as for other classes of lighting, with the specific modification in the choice of reflecting and diffusing equipment to meet the requirements of the particular application. These

various considerations will be discussed in their relation to the several types of installations.

43. Lighting for Stores.—The problem of store lighting is essentially that of providing good general illumination of substantially uniform standard throughout the store. The recommended practiee is to provide from 12 to 20 foot-candles, depending on the type of store and its location. Stores handling art goods, colored fabrics, clothing, furs, and such materials where minute examination of the design, texture, or color is essential to selection of the merchandise, require more light from the standpoint of vision alone, than do drug, tobaceo, grocery stores, and the like where the greater part of the merchandise is marketed in familiar packages, and where close examination of the goods is not so important.

It is a fact, however, that light plays such an important rôle in advertising the store by virtue of the attractiveness of a bright well-lighted appearance, that merchants of all classes are alert to take advantage of it. A few years ago, grocery stores, markets, and similar stores handling consumable necessities were very poorly lighted. More reeently, competitive conditions among these merchants have demonstrated that the well-lighted store attraets more customers, and high standards of illumination are being installed largely for the advertising value. For this reason any definite foot-candle standard would be misleading, since the amount of light that a store might profitably install depends on many factors other than the requirements of vision.

In store lighting the problem differs from that of the factory, inasmuch as the need is not primarily one of directing the light predominantly toward a horizontal working plane. Since goods are displayed on shelves and in wall cases, it is necessary to distribute the light so that vertical surfaees are well lighted. In faetories, light striking the side walls is largely wasted; in the store it is this distribution of light that allows display of merchandise to good advantage, and at the same time serves to create a bright and inviting appearanee.

44. Types of Commercial-Lighting Units.—Various types of commercial-lighting units are illustrated in Fig. 18. The

most common store-lighting units are the enclosing globes of white opal or prismatic glass, which effectively diffuse the light in all directions, and consequently are effective in lighting vertical or inclined surfaces such as shelves, racks, and upright displays. Enclosing units of the types shown in (*a*) and (*b*) are available in a wide variety of shapes and contours, although the lighting results do not differ materially. Units of the shape illustrated in (*a*) throw more light toward the walls than do units of the squat type (*b*); the latter type is more commonly used because it directs the light more strongly downwards to the counters and display cases. Both of these types are classified as direct-lighting units. A third type of the enclosed direct-lighting class is the prismatic-glass unit shown in (*c*).

Direct-lighting units of this character, though of somewhat higher brightness than would be recommended for offices, are applicable to stores because no one is required to face the units for long periods, since the clerks and store customers are constantly moving about. The moderate brightness of such units is an advantage from an advertising standpoint, since the higher brightness of the globes lend a feeling of alertness and attractiveness to the interior.

Semi-indirect and indirect units of the types shown in (*d*), (*e*), and (*f*) are frequently used, but their best application is for certain sections of department stores and for exclusive small shops where it may be desired to create a subdued and more restful atmosphere. Such equipment provides even, shadowless illumination free from disturbing glare or glint reflections from polished fixtures and furniture. The globe shown at (*d*) is a dust-tight, semi-indirect unit with what is known as a prismatic top, while the globe at (*e*) is also a dust-tight semi-indirect unit but with a clear top. The unit at (*f*) is a totally indirect one throwing all the light upwards to the ceiling and walls from which it is reflected.

The actual choice between direct lighting and some form of indirect lighting will be governed by the character of the store, the atmosphere desired, and to some extent the nature of the interior-decoration scheme. In this connection note Fig. 19, which shows the individual decorative treatment given the fix-

Fig. 18

Fig. 19

tures in the children's department of a shoe store. The 200-watt, semi-indirect lighting units are spaced 11 feet apart and give a soft, uniform illumination of approximately 7 foot-candles on the working level. The use of 300-watt lamps would provide approximately 12 foot-candles in this store.

45. Artificial-lighting installations in all stores should take full advantage of the decorative possibilities of light to create a charming and attractive interior. Such decorative treatment may be incorporated in the design and ornamentation of the lighting units themselves or it may be provided by the use of decorative colored lamps to give a distinctive tone. Also, instead of the methods just mentioned, the general lighting may be supplemented by employing small colored lamps behind decorative panels of glass, around columns, or small built-in coves, flower boxes, wall urns, and niches; in fact, the possibilities of attractive decorative touches of light are limited only by the imagination and skill of the designer.

Many of the larger department stores and exclusive small shops have closely followed the trend in modern art in the matter of decoration and interior finish. The trend has shown a distinct departure from traditional and classic forms, and the trend in lighting design has kept pace. In many cases the lighting method has followed past practice except that the lighting fixtures reflect a freshness of design along modern lines with many new and unusual forms. In other cases, the flexibility of incandescent lamps affords an opportunity to build the lighting system into the architectural composition of the interior. This logical step has taken the form of ceiling and wall coves, large areas of glass ceiling panels, artificial windows, and luminous wall panels, all of which become integral elements of the decorative scheme.

Regardless of the type of lighting employed, it is important to keep in mind, first of all, the lighting requirements from the standpoint of sufficient light, well diffused, and satisfactory for clear vision to aid in the accurate selection and judgment of merchandise. The light should be of such a color value that the merchandise is shown in its true color. Proper attention to

the quality of the lighting will lessen the amount of returned goods, and the disappointments occasioned by the selection of merchandise under lighting different in color quality from that where the goods are used. For example, in stores displaying evening gowns, the illumination might well be modified to a warmer tone than usual by the use of flame-tint lamps or small lamps in decorative shades to approximate the illumination of a ballroom or drawing room.

46. Daylight Quality.—The so-called daylight lamp produces a whiter light than the ordinary clear bulb. This quality of light is frequently desirable for general illumination in clothing, art, dry goods, and similar stores, where the daylight appearance of the merchandise influences the sale. In jewelry stores the white light gives fine gems a sparkling whiteness and purity that does not appear when ordinary lamps are used.

In the final analysis, however, the choice between clear and daylight lamps for general illumination is largely a matter of preference. The clear lamp offers higher efficiency and a warmer quality of light, while the daylight lamp offers better color discrimination and a better blend with natural daylight illumination.

47. Color-Matching Units.—Accurate color matching, as required in the departments handling yard goods, thread, ties, hose, and other colored merchandise, makes a perfectly white light desirable. To obtain true white light, accurate color filters must be employed, particularly for use locally on show cases and counters where comparisons should be made easily. Such units are available in various forms. An important requirement of a unit for accurate color matching is that a high intensity be provided, since a strong light is essential to bring out all of the many tints and shades that may be present. The color tone of a colored material is definitely related to the strength of the light under which it is viewed. The better types of equipment provide both corrected and unmodified light sources, so that comparison may be made under both qualities of light.

48. Show-Case Lighting.—Tests show that more merchandise is sold out of lighted show cases than from unlighted ones.

Lighted cases compel notice, and because people stop to look at the lighted displays, more sales are made. In general, display cases should be lighted with from 2 to 4 times the foot-candle illumination of the general store lighting. The standard practice is to use from 25 to 50 watts per running foot of show case. Small mirrored-glass reflectors using standard inside-frosted lamps, or small metal reflectors designed to accommodate long tubular lamps are standard for show and display cases. They can be mounted very inconspicuously along the front edge of the case. One form of 25-watt tubular lamp, designed for this service, is about 6 inches long and $\frac{3}{4}$ inch in diameter, and is especially suited to the lighting of display cases because of the small space required. The heat of the lamps must be considered when the merchandise is candy, wax ornaments, etc.

49. Show-Window Lighting.—The effectiveness of a window is dependent on the illumination, both from the standpoint of permitting the display to be examined and from the manner in which a brightly lighted window will assert itself to the passerby. Tests have been made to determine the effect of varying degrees of window illumination on the attracting power of display windows. When the illumination was increased from 15 to 40 foot-candles, 33 per cent. more people stopped to look at the displays. When the illumination was raised to 100 foot-candles, a further increase of 30 per cent. was noted in the number of persons attracted to the window.

Sufficient outlets should be provided to furnish the flexibility and control of illumination and lighting effects that are desirable for any particular display. The use of colored lighting in windows as an attention-getting medium adds an unlimited field for variation in decorative effects.

The illumination requirements for display windows vary with the character of the store and its location. A store in a small town, where the surroundings are not bright, will not require the window illumination necessary for a large downtown store in a white-way district where the windows vie with one another for attention from the shoppers. Desirable window illumination ranges from 30 to 150 foot-candles.

50. Window-Lighting Equipment.—Display windows can be lighted most effectively and economically by the use of reflectors designed specifically for this service. The common types of window-lighting reflectors have reflecting surfaces of prismatic glass, mirrored glass, or metal, which efficiently direct the light upon the display. These are available in several shapes to provide correct illumination for either deep or shallow windows. Care should be taken to choose that particular type of reflector which will most effectively distribute the light according to the window proportions. Specially designed prismatic glass plates set flush with the ceiling, with lamps and reflectors behind the plates, offer a very satisfactory method of lighting window displays.

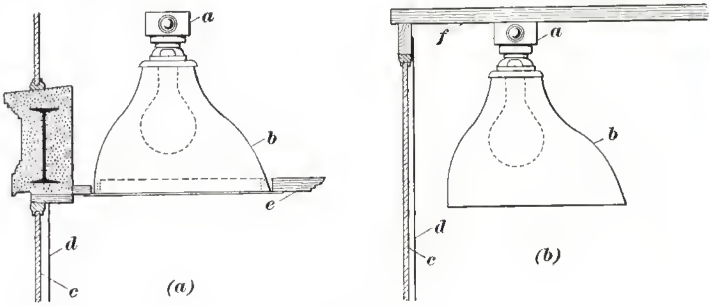


FIG. 20

51. Window-Lighting Installations.—The test of a good window-lighting installation is efficient distribution of light upon the display without loss upon the street, and without glare from exposed lamps. The usual practice is to locate outlets at regular intervals along the window front, and along the sides when the window is deep. In island windows, concentrating reflectors should be placed around the entire window. An island window is one that stands out by itself, as in the entrance vestibule of a large store, and people can walk completely around such a window.

The method of installing window-lighting equipment depends entirely on the construction of the window. Unless the ceiling is especially high, the reflectors are generally mounted on the ceiling close to the window as in Fig. 20 (*b*). Frequently, it is

desirable to conceal the equipment in a box or trough built in the upper front corner of the window. Where the window has a false ceiling, it may be preferable to install the reflectors above the ceiling with the openings flush with the ceiling, as in Fig. 20 (*a*), metal molding being used for finishing. In both views (*a*) and (*b*), the conduit fitting is shown at *a*, the reflector at *b*, the plate glass of the window at *c*, and the drapery at *d*. In view (*a*), a false ceiling is shown at *e*, and in view (*b*), a true ceiling at *f*. Where the distance above the window glass to the ceiling is fairly large, it will usually be found best to support the reflectors by brackets on the transom bar close above the window glass, either by individual brackets for each unit, or by supporting the conduit from which the units are suspended.

The spacing and size of lamps used will depend on the illumination requirements. In the better illuminated windows a 12-inch spacing is common. In practice, then, the spacing usually falls within the range of 12 to 24 inches. Outlets should be available for the use of spotlight or floodlight projectors when desired. When once an adequate number of outlets has been installed, the illumination can be varied at will by manipulating the size of lamp used, or by arranging the lamps on two or more circuits so that alternate lamps may be turned on or off. Lamps employed in show-window lighting range from 100 to 200 watts in size.

52. Overcoming Daylight Reflection.—Studies have been made in the use of light for overcoming daylight reflections from plate-glass windows. It is a matter of common experience that reflections of objects such as buildings on the opposite side of the street, of passing street cars and automobiles, and of people passing on the sidewalk, often make it almost impossible to see into show windows. To overcome such reflections, a number of installations are in use employing high illumination intensities of the order of 200 to 500 foot-candles of artificial lighting. Such systems are turned on during the daytime, with the result that reflections are greatly reduced or entirely overcome. The severity of these reflections depends not only on the brightness of the objects in the street, but also to a considerable extent on

the color of the window background. If the background is light-colored and if a high degree of illumination is provided, the brightness of the display is increased to such an extent as to overcome the brightness of images reflected from the surface of the plate glass. Installations for this purpose are exactly similar to any modern window-lighting installation, but require the equivalent of 500-watt lamps spaced 12 to 15 inches apart.

WINDOW IN FEET		HEIGHT OF DISPLAY OR SOLID BACKGROUND IN FEET							
Height	Depth	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16
4-6	1-4								
	4-5								
6-8	2								
	3-7								
	7-9								
8-10	2-4								
	4-6								
	6-8								
	8-12								
10-12	3-5								
	5-8								
	8-10								
	10-12								
12-14	4-6								
	6-10								
	10-12								
	12-14								
	14-16								
14-16	4-6								
	6-8								
	8-12								
	12-14								
	14-16								

CONCENTRATING

DISTRIBUTING

CONCENTRATING DISTRIBUTING

FIG. 21

53. Show-Window Chart.—The information on show-window lighting might be supplemented by Fig. 21, which indicates the type of reflector best adapted to the distribution of light according to the window dimensions. This chart indicates the dividing line in the choice between concentrating and distributing types of window reflectors. For example, according to the chart, if the window is 11 feet high and has a depth of

4 feet, and the height of the display or solid background is between 8 and 10 feet, then a distributing type of reflector should be used. If, however, with the same window dimensions, the height of display or solid background is from 6 to 8 feet, then a concentrating type of reflector should be used.

54. Suggestions in the Use of Colored Light.—Color is attractive and commands attention. Plenty of colorless light from clear or daylight lamps is effective where the goods are displayed primarily for the convenience of the customer in making a selection, but the proper use of colored lighting enhances greatly the more artistic window displays, and tests have shown that, for equal wattage, color in the lighting increases considerably the attention value of the display window.

The secret of the successful use of colored light is in making the color suit the display. Each color tends to produce a certain definite atmosphere and psychological effect, as outlined in the following list:

Red.—The most striking and lively color. Suggests action, fire, passion, tragedy, heat, danger.

Rose.—Soft and inviting. Suggests health, beauty, love.

Orange.—Vivid and gay. Suggests warmth, the autumn.

Yellow.—Cheerful and inspiring. Suggests light, sunshine, happiness, springtime.

Green.—Cool and refreshing. Restful and soothing to the eye. Suggests life, vigor, youth, summer, the outdoors.

Blue.—Soothing and subduing. Suggests coldness, the night, moonlight, winter, symbolic of truth, fidelity, dignity, stability.

Purple.—A rich and royal color. Suggests luxury, splendor, dignity, or may give a somber or mysterious impression.

White.—Suggests light, purity, cleanliness, peace.

The various colors and tints may be obtained by the following combinations of lighting units:

Red Tint.—One white to three or more red units.

Rose.—Red and blue units in equal numbers.

Orange.—One amber to two red units.

Yellow Tint.—White and amber units in equal numbers.

Green Tint.—One white to four or more green units.

Yellowish-Green.—One amber to three green units.
Greenish-Blue.—One green to three blue units.
Blue Tint.—One white to five or more blue units.
Violet.—One red to two or more blue units.

In general, a color tint or a combination of two or more color tints is preferable to a solid pure color. It is usually advisable to determine by experiment the color effects which are best suited to each particular display. Striking results are obtained by the use of a spotlight to focus clear light on the central object of the display, while the rest of the window is flooded with harmonizing colored light.

The effective use of color requires a flexible system of window-lighting equipment and circuits to permit easy control of the variations of light intensity, direction, and color combinations that are desired. Where color lighting is used, the window background is usually of a light neutral gray, in order to be readily adaptable to the color effect produced by the lighting.

INTERIOR LIGHTING PRACTICE

Serial 2718B (PART 2) Edition 1

THE LIGHTING FIELDS—(Continued)

OFFICE AND DRAFTING-ROOM LIGHTING

1. General Discussion.—Lighting units of the indirect or semi-indirect types, that is, those which direct the greater portion of the light to the ceiling, from which it is reflected to the desks, provide the best illumination for offices and drafting rooms. Completely enclosed units of these types are preferable from the standpoint of minimizing dust collection and making maintenance easy.

Where indirect or semi-indirect lighting is impracticable because of ceiling finish, as, for example, one with a skylight or one that has a dark-colored finish, then direct-lighting enclosing globes are employed. However, it is best to avoid direct-lighting units because of the higher brightness; though at casual glance such units may not seem to be glaring, the effect of sitting all day long facing a row of even moderately bright units is apt to be trying on the eyes. To obtain efficient lighting with indirect or semi-indirect systems, the ceiling and upper side walls should be kept light in tone, either white or slightly tinted. The wall color should be of a medium tone, such as a light olive-green, light buff, or dark cream. Lighter tones for walls do not aid materially in the efficiency of the lighting, and are apt to prove uncomfortable to face for long periods. Glossy paints should be avoided, and all woodwork, desks, and tables should have a dull finish.

Individual desk lamps are practically never recommended for the principal lighting of large general offices because of the likelihood of glaring reflections, harsh shadows, and contrasts

of brightness with the surroundings. A very commendable form of office lighting is by the use of portable table and floor lamps with an indirect reflector. Such lamps serve the same purpose and produce the same quality of illumination as indirect equipment suspended from the ceiling. Portable lamps with their decorative shades add a certain amount of charm to any room. The use of such portables is recommended for their flexibility and the ease with which they can be adapted as supplementary to an inadequate system of overhead lighting.

2. Office Units Preferably of Low Brightness. — The recommendation of semi-indirect or totally-indirect lighting for

TABLE I

GLOBE SIZES RECOMMENDED FOR LAMPS OF GIVEN WATTAGE

Size of Lamp Watts	Globe Diameter Inches	
	For Stores	For Offices
150	12	14
200	14	16
300	16	18
500	18	20
750	20	22

offices is based on the desirability of well-diffused, soft light with a minimum brightness of units. A good indirect-unit will have an output of 75 to 85 per cent. of the light of the bare lamp. A semi-indirect unit should have such density of glass in its globe that not much more than 20 per cent. of the light comes directly downwards from the bowl itself. From the standpoint of good design and appearance of the installation, it is preferable that the upward light from the units be fairly evenly distributed over the entire ceiling, rather than be concentrated in small bright circles directly above the units. Inside frosted lamps are now available in sizes up to 500 watts and their use in semi-indirect and indirect fixtures will relieve sharp lines of cut-off and harsh shadows on the ceiling due to suspension chains or rods.

The maximum brightness of semi-indirect units, viewed at any angle from below, should not exceed 2.5 candlepower per square inch. Where conditions of ceiling color or maintenance make it necessary to use direct-lighting enclosing globes for offices, the units will produce a higher brightness than that just stated. However, larger globes for a given size of lamp than would be specified for stores, are recommended in order that the brightness will not exceed 4 candlepower per square inch. Table I shows the sizes of globes recommended for lamps of various wattage.

3. Number of Units Required.—Since the ceiling height of the majority of offices is around 10 to 12 feet, there exists a fairly definite relation between the floor area of an office and the number of units needed to obtain satisfactorily uniform illumination. Thus, in a small office whose area is less than 400 square feet, one lighting unit for every 70 to 90 square feet is recommended, and the area per unit should not exceed 100 square feet. For example, an office 9 feet square should have one lighting unit; an office $9' \times 18'$ should have two units, and an office 18 to 20 feet square will require four lighting units.

In large office spaces exceeding 400 square feet, there should be an overhead lighting unit for every 90 to 110 square feet of floor area, and the square feet per lighting unit should not exceed 145. For example, an office $20' \times 30'$ should have six units; an office $22' \times 60'$ should have twelve units. As suggested previously, these figures are based on average ceiling heights; where higher ceilings prevail, correspondingly greater floor area per lighting unit is permissible.

4. Size of Lamp.—For general office work, at least 15 foot-candles should be provided, while for drafting rooms 25 foot-candles are recommended. Under average conditions of installation, in accordance with the spacings mentioned above, the 300-watt unit will provide about 15 foot-candles, and 500-watt units will be required to produce 25 foot-candles. These results will vary with the character of the room, interior finish, and maintenance conditions. Accurate design data should be referred to in checking the illumination for every lighting layout.

SCHOOL LIGHTING

5. General Discussion.—Because of the prevalence of defective vision among school children, the percentage increasing with each age group, more attention is being paid to school lighting. This, together with the fact that a good many schools are now used for evening classes, has made it desirable that only the best lighting system be provided.

The requirements for schoolroom lighting do not differ materially from those of office lighting. What has been said of office lighting is equally applicable to schools. The lighting layout for schools is simplified, since the dimensions of classrooms are fairly standard, the usual classroom requiring six 300-watt semi-indirect units.

6. Special Conditions.—The subject of school lighting introduces many other lighting applications for the special laboratories, gymnasium, shops, lockers, pool, kitchen, etc. These need not be discussed separately, since they involve methods covered throughout this lesson.

RESIDENTIAL LIGHTING

7. General Discussion.—The question of home lighting needs no lengthy treatment. The problem of adequate lighting for the home is largely a matter of adequate and convenient wiring facilities. The ability to place portable lamps exactly where one wants them permits an artistic arrangement of furniture that is not only pleasing as a picture, but livable in respect to normal night-time occupations of reading, sewing, or entertaining. Plenty of convenience outlets can be installed at a reasonable cost and the investment places both electric light and electrical appliances completely at one's disposal.

Present good practice is to provide at least one duplex outlet for every 50 square feet of floor area. This not only permits greater convenience and variety in illumination from either utilitarian or decorative portable lamps, but helps to avoid the nuisance of interfering with the lighting to accommodate household electrical appliances. It is impractical to run lamp or appli-

ance cords past doorways, and for this reason it is oftentimes desirable to install more outlets than are specified by this minimum requirement. The duplex outlet provides an extra outlet in one plate with practically no additional cost.

8. **Location of Outlets.**—A good place for convenience outlets is 18 inches above the floor. At this height, lamp cords drag much less, and the outlet is more readily accessible. In the bathroom and kitchen it is recommended that the twin outlets be installed about 48 inches from the floor. This height is also correct for basement outlets for hand ironing, ironing and washing machines, and work benches. Switchplates and outlet flush plates are available in almost any color, material, and finish so that they may be made quite inconspicuous.

9. **Lamps and Wall Brackets.**—Although portable lamps in their many forms offer a great flexibility and variety of lighting effects for every room, the foundation of good home lighting lies in the ceiling fixtures, which can hardly be dispensed with in any room. Such lighting from ceiling fixtures should be sufficient to see clearly, distinctly, and without eye strain. Glare must be avoided by shielding all lamps within the field of view. Bright fixtures must not be seen against a dark background. The lighting fixtures for each room must be in decorative harmony with its setting, as to design, material, finish, and color.

Decorative wall brackets are especially suitable for use in both the living and dining rooms. They should not be depended upon for much useful illumination for visual tasks, but merely for spots of luminous color, enlivening the surrounding wall spaces and brightening the general tone of the room. One switch may be used to control all of the decorative brackets in a room, thus eliminating the bother of going about the room to turn on each one separately.

Decorative brackets should be mounted so that the light source is about 72 inches above the floor; utilitarian brackets, such as are used for lighting at the mirror in bedrooms and the bathroom, and in the kitchen for light over the sink, should be about 66 inches above the floor. For upright brackets, the wires

should be brought out of the walls about 6 inches lower than the figures given for the other classes of brackets.

10. Switches.—Switches should be chosen from the standpoints of convenience, service, and appearance. The tumbler is the most popular type because of its greater convenience for children, and because it can be operated by the elbow if the hands are engaged. Switches should be located about 48 inches from the floor at the knob side of the most-used doorways and near the frame. Ceiling outlets are often conveniently controlled by providing two switches, placed at the main doorways, either of which may control all or part of the lamps in the ceiling fixture. Separate switches, one controlling all of the wall brackets, and one all of the convenience outlets, is a very useful and effective arrangement, particularly for the living room. The convenience outlets on one floor may be on a circuit separately fused from the circuit of the ceiling fixtures on the same floor, so that a blown fuse will not put out all of the lights in a room.

11. Suggestions.—Various electrical organizations have endeavored to improve standards of home wiring by developing wiring suggestions setting forth the minimum number of electrical outlets for each room of a house. A set of such minimum wiring standards is given in the next article. It should be remembered that these are minimum recommended standards and many homes are providing many additional switches, and lighting and appliance outlets.

The growing custom of outdoor decorative lighting for Christmas and other festive occasions has made it desirable to locate weatherproof outlet boxes about the exterior of the house and the garden. Where the grounds are well landscaped with trees and shrubs, very beautiful and charming effects may be secured by concealed floodlights playing a flood of colored and tinted light upon the flowers and foliage.

If ceiling fixtures and portable lamps are chosen with the proper degree of care, equipped with shades of good design and of sufficient density, ample light will be available for all utilitarian purposes. However, the possibilities that light offers from a purely decorative and artistic standpoint should be given

equal consideration. These possibilities range from the simple touch of color given by a wall-bracket, by a torch or by color shadows from a lighted ornament, to elaborate colored fountains and artificial skylights for the more pretentious homes. As a suggestion the following might also be mentioned: wall pockets wall urns, silhouette ornaments, lighted vases, flower boxes, fish bowls, wall plaques, picture lighting, small inconspicuous cove sections above doorways and windows, artificial windows, and lighted cabinets. Skilled interior decorators regard light as one of the most potent and flexible elements in home decoration.

When once the home is adequately and completely wired, there is no end to the suggestions that might be made to indicate how lighting serves for beauty, convenience, comfort, and safety in the home.

12. Minimum House-Wiring Standards.—The following house-wiring standards were recommended by a prominent electrical league:

Outside Entrances.—One ceiling or one side outlet. One single-pole switch.

Porches.—One ceiling or one side outlet. One single-pole switch. One convenience outlet, 18 inches from the floor, if the floor area is in excess of 100 square feet.

Vestibule.—One ceiling or side outlet and one single-pole switch if the floor area is in excess of 16 square feet.

Hall.—One ceiling outlet and one single-pole switch. If there are two doorways more than 10 feet apart, two three-way switches.

Convenience outlets, one for each 12 feet of baseboard to be installed in the wall or the baseboard approximately 12 feet apart.

Stair Hall.—One ceiling outlet and two three-way switches.

Convenience outlets, one for each 12 feet of baseboard to be installed in the wall or the baseboard approximately 12 feet apart.

Living Room.—One ceiling outlet if the room is nearly square. If the length is more than $1\frac{1}{2}$ times the width, two ceiling outlets, or four wall-bracket outlets may be substituted for one ceil-

ing outlet, or six wall-bracket outlets may be substituted for two ceiling outlets. For one doorway, one single-pole switch. For two doorways more than 10 feet apart, two three-way switches.

Convenience outlets, one for each 12 feet of baseboard to be installed in wall or baseboard approximately 12 feet apart.

Living-Room Mantel.—Two side outlets in the wall above the mantel, or two convenience outlets in the mantel shelf.

Sun Room.—One ceiling outlet. For one doorway, one single-pole switch. For two doorways more than 10 feet apart, two three-way switches.

Convenience outlets, one for each 12 feet of baseboard to be installed in the wall or the baseboard approximately 12 feet apart.

Dining Room.—One ceiling outlet. For one doorway, one single-pole switch. For two doorways more than 10 feet apart, two three-way switches.

Convenience outlets, one for each 12 feet of baseboard to be installed in the wall or the baseboard approximately 12 feet apart.

Breakfast Room.—One ceiling outlet. One single-pole switch. One duplex convenience outlet just above the level of the table top.

Kitchen.—One ceiling outlet. For one doorway, one single-pole switch. For two doorways more than 10 feet apart, two three-way switches. One ceiling or side outlet over sink controlled by a switch or a pull chain. One duplex convenience outlet 4 feet high, near the sink.

Refrigerator Room.—One ceiling outlet. One single-pole switch. One convenience outlet.

Rear Hall.—One ceiling outlet. For one doorway, one single-pole switch. For two doorways more than 10 feet apart, two three-way switches.

Hall, Second Floor.—One ceiling or side outlet. Two three-way switches. One convenience outlet 4 feet from the floor.

Bedrooms.—One ceiling outlet. One single-pole switch. Convenience outlets, one for each 12 feet of baseboard to be installed in the wall or the baseboard approximately 12 feet apart.

Closets.—One lighting outlet controlled either by a pull-chain or the door switch, if the floor area is in excess of 10 square feet.

Bathroom.—Two side-wall outlets, one on each side of the mirror located 5 feet from floor. One single-pole switch. One duplex convenience outlet at the right of the lavatory 4 feet from the floor.

Basement.—One ceiling outlet for each 150 square feet of floor area. One switch located at the head of the stairs.

Laundry.—Two ceiling outlets, one over the laundry trays, one over the ironing machine. One switch if the laundry is enclosed. One outlet in the ceiling, 3 feet in front of the center of the laundry trays, for *clothes washer. One convenience outlet for hand iron and ironing machine.

Fruit Room.—One lighting outlet.

Boiler Room.—One lighting outlet.

Coal Room.—One lighting outlet.

Single Garage.—Two ceiling outlets 5 feet from the rear wall and $8\frac{1}{2}$ feet apart. One outside outlet. Two three-way switches, one in the garage and one inside the house. One duplex convenience outlet in the center of the rear wall 4 feet from the floor.

Double Garage.—Three ceiling outlets in line 5 feet from the rear wall. The remaining requirements are the same as for a single garage.

PUBLIC-BUILDING LIGHTING

13. General Discussion.—Public buildings are a part of the so-called commercial-lighting field but, because of the diversity of problems encountered and the unusual treatment oftentimes necessary, they really embrace a special technique in the matter of lighting. Most public buildings are semi-commercial in the sense that they all seek to attract and interest the public in the services they represent. This applies to libraries, museums, churches, hospitals, and such institutions as well as to banks, theaters, gymnasiums, and auditoriums, all of which must appeal to the public for good-will and patronage.

*Note.—The outlet for the clothes washer shall be equipped with a porcelain key socket hung $5\frac{1}{2}$ feet from the floor

It is obvious that, in the lighting of a theater auditorium, a vaulted church dome, a spacious bank lobby, a hospital operating room, or a college gymnasium, each requires a different treatment to meet the essential requirements. At the same time, among buildings of the same class, each requires an individual treatment of the lighting to conform to the structure itself, to be in harmony with the architecture, and to lend whatever atmosphere it may be desired to create.

Lighting for public buildings serves several purposes. First, it should be adequate from the standpoint of pure utility, and it must conform to all of the principles of good illumination. Its quality as far as diffusion, distribution, and color are concerned, and its quantity to best serve the visual requirements must be satisfactory. The second purpose is to serve the aesthetic or decorative needs. To do this the lighting effect must be pleasing, the fixtures should harmonize with the decorative scheme, or, in the case of concealed light sources, the lighting should be an integral part of the architecture itself.

Only within recent years has there come a general appreciation of the fact that the incandescent lamp is a versatile illuminant that can be used in many ingenious ways. Many of our methods of lighting were handed down to us from the limitations of the candle, oil lamp, gas, and other flame sources, and it has been difficult to break from the traditional methods of both fixture design and disposition of the light sources. Traditional forms of architecture, too, never embraced artificial light sources as a part of the structure itself, since with flame sources, that was out of the question. Now, however, with the freedom that has come with modern art, architects and designers have realized that it is only logical to treat artificial lighting as a part of the architectural composition just the same as windows and other openings are treated with regard to admitting natural daylight.

There are a number of ways in which lighting may be incorporated as a part of the building design. These may take the form of artificial skylights, windows, coves, urns, or other concealed sources for indirect reflectors and projectors; in addition there are many ingenious methods for disposing of lamps behind glass panels for color effects and luminous decorations. While

these forms may be applicable to many types of buildings, the public and monumental commercial buildings have generally pioneered in such installations.

For each type of interior there may be a lighting treatment which emphasizes the character of that type in the most appropriate manner. Many rooms call for decorative touches and refinement that are entirely independent of the general illumination. The introduction of color presents an entirely new realm of appeal which is infinite in its possibilities in harmony, and in range of psychological sensation.

Before discussing some of the more important lighting requirements encountered in different classes of buildings, a number of general methods applicable in many types of construction will be described.

14. Lighting From Concealed Sources.—Indirect lighting from concealed sources, characterized by the absence of bright light sources and by a minimum of shadows, might be compared to the illumination out of doors with an overcast sky. Since all indirect systems depend on reflection of the light from the ceiling or other large diffusing surfaces, they are applicable only where these surfaces are finished in light-colored materials and are well maintained.

Indirect lighting lends itself to a variety of forms, namely. continuous coves, cove sections, wall boxes, pedestal urns, and artificial windows. However, such illumination does not differ materially from that produced by ordinary indirect units suspended from the ceiling. The actual form of indirect lighting used will depend on the provisions made for this sort of system, either as a part of the architectural plan or as fitting harmoniously into the decorative mode of the interior.

15. A detail section of a cove lighting installation showing the reflector in its relation to the cove is indicated in Fig. 1. This method of indirect lighting is used in the bank building shown in Fig. 2. The lights are wholly concealed from the observer on any part of the floor. They are placed in the coves, which run all the way around the top of the rooms just under

the edges of the ceiling. The reflectors *a*, Fig. 1, are placed on angle receptacles *b*, so that they can be adjusted to direct the light at the proper angle to the ceiling, from which it is reflected to all parts of the banking rooms. Other typical coves are shown in Fig. 3 (*a*) and (*b*). In view (*a*), the reflectors such as at *a* are mounted on special brackets *b* spaced 4 feet between centers. The finished plaster ceiling of the interior is shown at *c*, and the surface at *d* is painted white. An access opening is shown at *e*. In view (*b*), the reflector is indicated at *a*, the holder at *b*, the lamp at *c*, the socket at *d*, the outlet box cover at *e*, and the inside cornice at *f*.

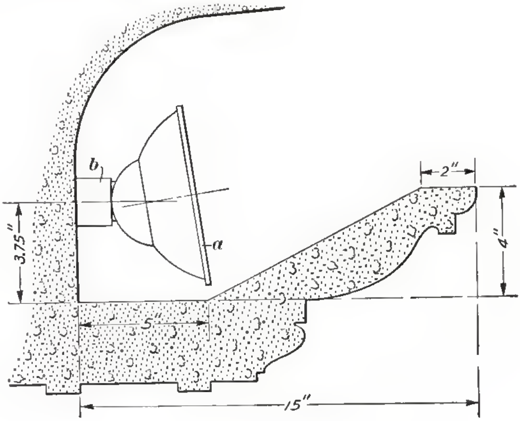


FIG. 1

Cove lighting in a variety of forms has been adapted to many classes of buildings. It is applicable wherever the architectural design permits the installation of the cove around the walls at an appropriate height. It is particularly favorable where the ceiling is curved from the walls to form an arched ceiling or dome. In other cases a number of small coves may be employed in a series of circular or rectangular shapes in a coffered ceiling, that is, by having a number of ceiling coves in separate bays formed by beams and cross-members which support and form the cove construction. Such cove sections may serve the dual purpose of lighting art panels within and at the same time reflecting enough light for general room illumination.

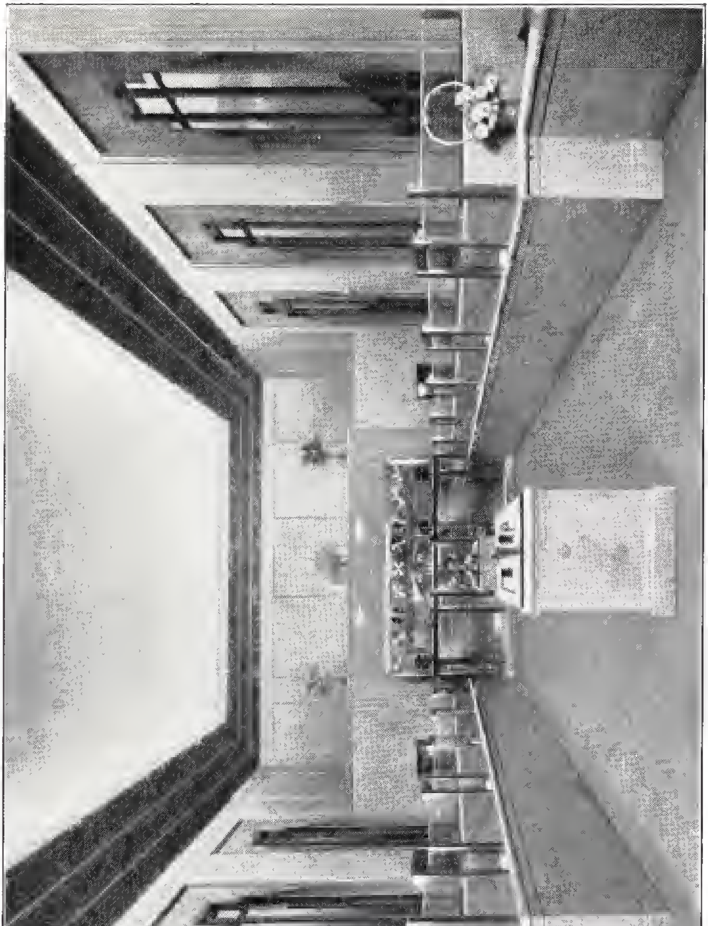


Fig. 2

In cove lighting, good appearance requires an even distribution of light over the entire ceiling or other reflecting surface. The cove structure must allow for complete concealment of reflectors; the units must be closely spaced and of such a design that the ceiling near the cove is not excessively bright. Scallops of light and shadow should be avoided by close spacing of units and use of frosted lamps. The spacing must be such that an occasional lamp failure will not give a ragged appearance.

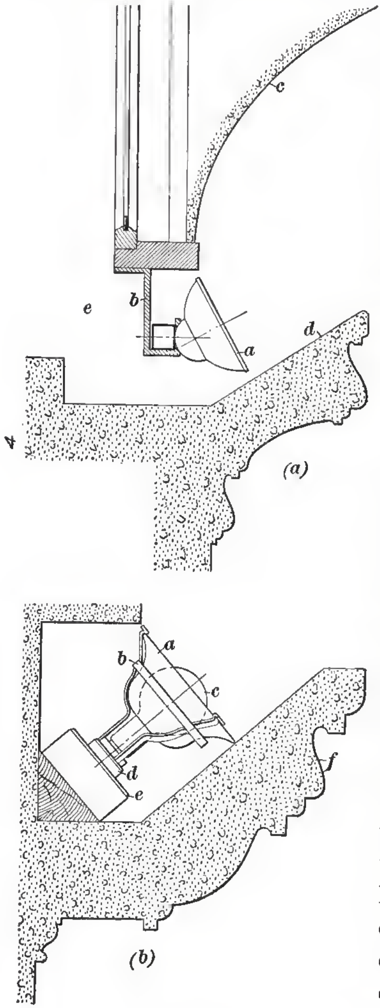
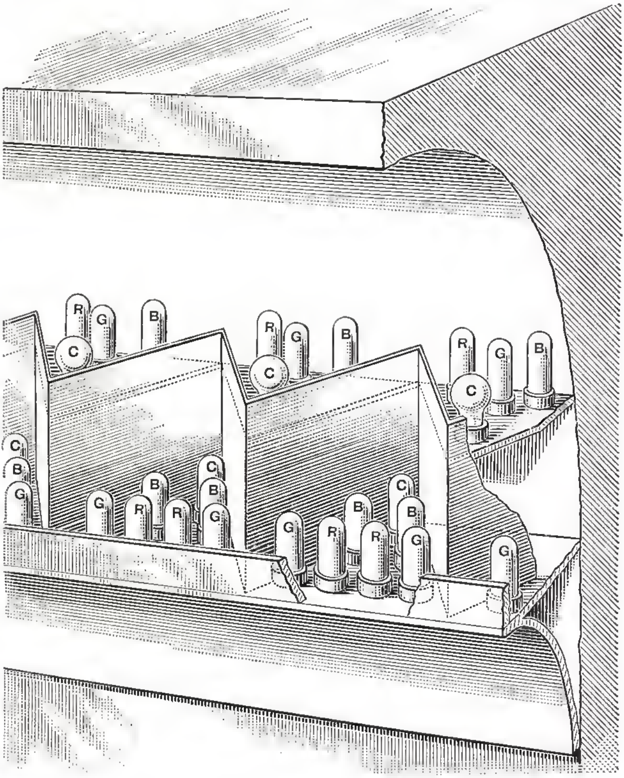


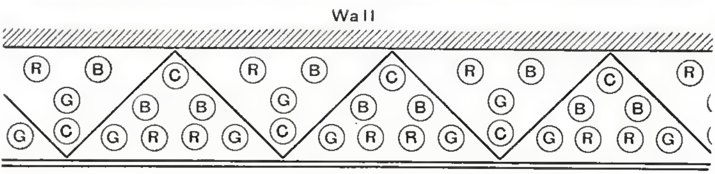
Fig. 3

The type of reflector used will depend on the ceiling contour, the distance the light must be projected, and the location of the cove with respect to the ceiling. Many types of cove lighting reflectors are available and the choice of any reflector will be governed by the conditions encountered. Because of the necessity of using closely spaced reflector units, small lamps of 40 to 150 watts are usually employed. Because of the lower efficiency of the lower wattage lamps, and because a cove system is less efficient than commercial types of indirect luminaires, the wattage required to produce a given foot-candle level with a cove system will be higher than with indirect luminaires. Where cove installations are used as the principal source of illumination, it is customary

to estimate the total lumens required on the basis of ordinary indirect equipment. While cove systems compare favorably



(a)



(b)

Fig. 4

with other indirect systems, an additional wattage allowance, because of additional lumens, is usually necessary for light trapped in the cove.

16. Color Effects.—The usual way to produce color lighting in interiors such as theaters, ballrooms, and auditoriums is by color equipment in coves. In these cases several color circuits are provided. There are two methods used to equip the cove units with colors; one is by means of colored lamps and the other by using colored-glass plates over the front of the reflectors. The latter method is preferred because the uniformity of color effects is not affected by new lamps, which are likely to vary in color.

Rather elaborate color cove systems have been developed under the name of *colorama*. Such systems have been used as the principal decoration of large public rooms; by a series of color coves around the walls and on sides of ceiling beams, the entire room may be bathed in flowing, changing colors. By unusual grouping of color lamps and careful arrangement of control circuits, endless patterns of color shadows and colored designs may be produced. A section of a colorama cove is shown in Fig. 4 (*a*) and a plan of such a cove in view (*b*). In this illustration, the lamps are lettered as follows: *B* meaning blue; *C*, clear; *G*, green; and *R*, red.

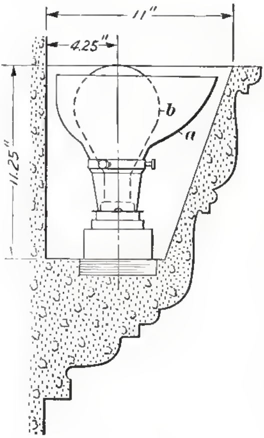


FIG. 5

17. Wall Urns and Box-Type Units.—Many times it is not practical to construct a continuous cove or built-in cove sections, but it is nevertheless desired to illuminate the interior by hidden reflectors. For this purpose there are reflectors of special design to distribute the light well over the ceiling without splashes of high brightness adjacent to the unit. A unit of this character, as installed in Fig. 5, is very applicable for use as supplementary lighting around columns, in box units above partitions, or above display cabinets and similar places. The reflector is indicated at *a* and a 200-watt lamp at *b*. Many banks are lighted by indirect reflectors in a continuous trough placed the

length of the row of cashier cages. These indirect reflectors are oftentimes supplemented with a circuit of direct-lighting units behind a glass plate which serves to light the cashier's cage directly.

Other methods of obtaining indirect lighting include floor pedestals, column clusters, and portable lamps. These methods are very flexible and can be used to furnish the entire illumination or to supplement other systems. Pedestal urns can be given any manner of exterior design and decoration.

18. Maintenance of Efficiency.—Cove lighting installations should be considered only when they can be made easy of access

TABLE II

REFLECTION VALUES OF ACOUSTICAL MATERIALS

Trade Name*	Description	Per Cent. Reflection
Absorbege	Natural color	64.5
Absorbege	White finish	72.3
Cushoeel	Natural color	11.8
Cushoeel	White finish	75.1
Corkcoustic	Natural color, chocolate brown	8.3
Corkcoustic	White finish	66.0
Masonite	Natural color, dark brown	15.1

*NOTE.—Tests of 70 samples of acoustical materials show a range between 6 per cent. and 75 per cent. in their light-reflection value.

for cleaning reflectors and replacing burned-out lamps. The best arrangement is one in which access may be had from a convenient walk at the rear of the cove. Such a scheme is shown in Fig. 3 (*a*).

The tendency in many offices and public buildings is to make use of acoustical materials on walls and ceilings for deadening sound. These materials, which are available under many different trade names, are oftentimes applied in their natural color and finish. Table II shows the reflection value of several different samples.

It will be noted that the natural-reflection factor of some of the materials is very low and not efficiently adapted for indirect-

lighting effects. Tests indicate that most of such materials can be furnished in light colors without destroying their acoustical

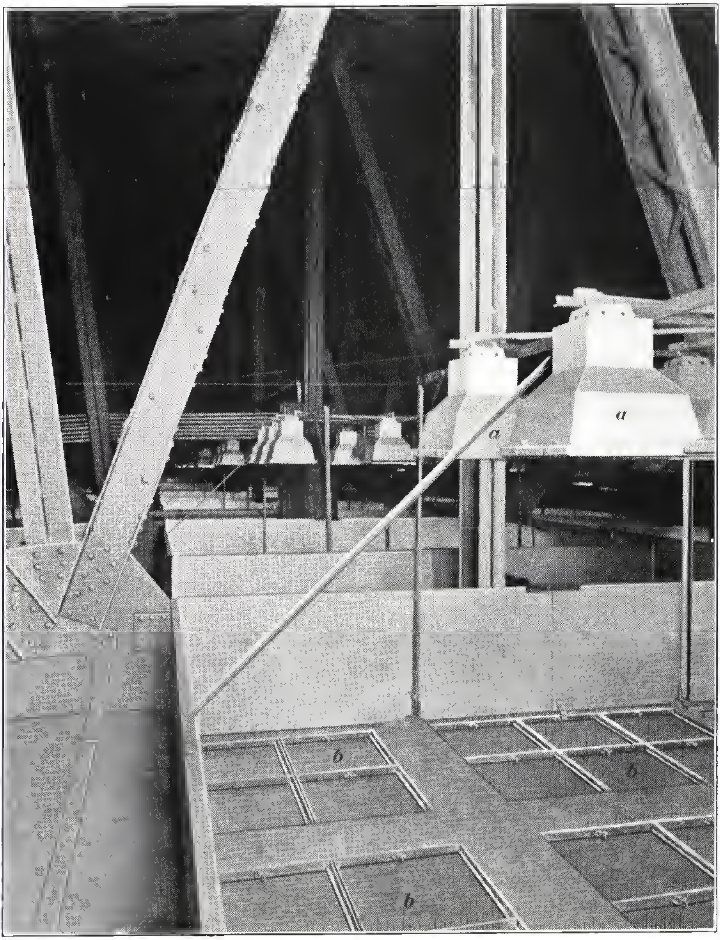


Fig. 6

properties, and in such cases their use will not seriously affect the efficacy of indirect-lighting systems.

19. Artificial Skylights.—Skylights have been employed in architecture, particularly for museums, libraries, bank lobbies,

and other large buildings. Provision for skylights to admit natural daylight demands quite expensive construction and maintenance and where they have been provided it is usually desired to incorporate also an artificial-lighting system to retain the lighting effect at night. In other cases, artificial skylights have been designed in which no daylight is admitted but rather they have been designed around the artificial-lighting system. This method is really more economical, since a more efficient artificial-lighting system may be planned, and the construction does not have to be as elaborate nor as expensive as if the skylight had to be made water-tight, and with control louvers and mechanism for regulating the natural light.

Several methods for lighting skylights have been used. One scheme employed in a large auditorium is shown in Fig. 6. It consists of large sheet-metal housings *a*, painted white inside, above each panel section *b* of the skylight. Each housing, with individual mirrored reflectors, contains several circuits for clear and colored lighting effects. This is probably the most efficient method for lighting of this character.

A second method used in lighting a museum makes use of projectors at some distance above the skylight. This is done to give greater uniformity of appearance to the skylight and to avoid bright spots. In some types of museum displays, general skylight effect is desired; in others, principally in art museums, it is desirable to light the walls predominantly, in which case the gallery walls are lighted effectively by directing the projectors above the skylight at the proper angle.

A third type of construction that has been employed for general skylight effect is a simple metal or wall-board housing over the entire skylight. With a white interior finish this housing acts as a huge reflector for lamps hung at regular intervals above the glass. A very interesting use of such a skylight is in a large museum in which the skylight is used to create an illusion of natural daylight. The edge of the skylight, however, as in Fig. 7, is bounded by ceiling beams *a*, in which a series of projectors *b*, Fig. 8, are cleverly concealed behind vertical ribbed-glass panels. The projectors direct a high-intensity band of light to the walls where the pictures are hung.

20. Luminous Panels and Beams.—The vogue of built-in lighting for many types of modern interiors has tended to create a wide interest among architects and decorators in luminous

Fig. 7

decoration. This is true particularly for lobby and corridor, club and lounge rooms, and high-class display rooms. The possibilities for such lighting treatment are very great, since

luminous panel sections may be disposed of in a large number of ways. Their success, however, depends to a large extent on

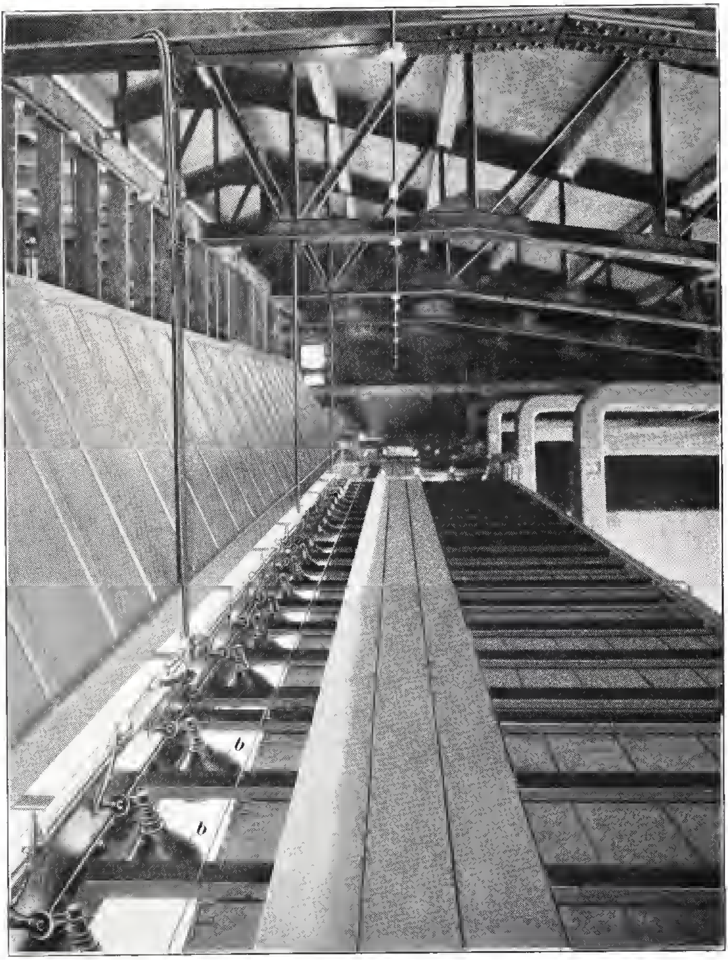


FIG. 8

how ingeniously this scheme of lighting is made a part of the architectural ensemble.

The problem involves merely the provision for inserting shallow boxes or troughs in the ceiling or walls, and fitting these

with glass panels. The inside of such boxes is usually finished in a flat-white paint to give good diffusion and the sockets are mounted at regular intervals within this housing. The lamps may be spaced to give uniform brightness to the entire panel, or in some cases a definite pattern of spots may be wanted, particularly where decorative grilles, color designs, or silhouette patterns are introduced.

Tests indicate that apparent uniformity is obtained where the ratio of the brightness at different points on the glass does not exceed 1.5 to 1. Beyond this ratio spottiness is evident. The degree of uniformity will depend on how close the lamps are to the glass in relation to the spacing between lamps. The type and density of the glass used is also important. For example, frosted glass with lamps 6 inches back of the glass, would require a spacing between centers of 3.3 inches; for flashed opal glass, equivalent uniformity would be obtained with lamps on 8.4-inch centers. The saving in wiring and lamp efficiency by the use of flashed opal is obvious. The characteristics of differ-

TABLE III

CHARACTERISTICS OF DIFFERENT KINDS OF GLASS

Character of Glass	Diffusion	Transmission Factor Per Cent.	Unlighted Appearance
Clear hammered	None	90–95	Gray against a cavity
Clear with cut designs	None	85–90	Gray
Clear sand hammered	Slight	70–85	Gray
Clear pebbled	Slight	65–80	Gray with texture
Sanded amber hammered	Fair	70–75	Amber tint
Clear antique	Slight	85–90	Gray against a cavity
Amber antique	Slight	75–80	Amber
Sanded amber antique	Fair	55–70	Amber
Opalescent	Fair	60–85	Light gray with some texture
White opal	Good	10–45	White
Flashed opal	Good	50–70	Light gray

ent glasses used for skylights and for luminous panels are given in Table III.

21. Prismatic-Lens Control. — In many instances very desirable and effective control of light distribution from ceiling panels can be accomplished by means of prismatic plates set flush with the ceiling. A control plate of this sort is shown in Fig. 9. Such a plate, used in conjunction with a lamp and reflector back of the plate, is available in different sizes and

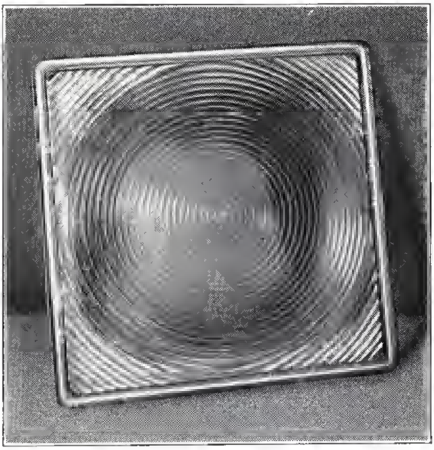


Fig. 9

with different refracting characteristics. It may be used to concentrate the light in a small spot or it may be used to spread the light out into a band. By offsetting the lamp from the focal position, the light may be directed at an angle.

Units of the type just described have been very effectively used in show windows, art museums, banks, gymnasiums, and other places where it was desired to avoid the use of suspended equipments, and at the same time retain accurate control of the direction and distribution of the light. For example, one of the most effective types of hospital operating-room units consists of an assembly of plate lens control units as shown in Fig. 10. This 18-section equipment consists of a metal framework 6.5 feet by 13.5 feet, holding 18 prismatic plate units

Fig. 10

with a 150-watt lamp behind each. Each lamp and lens combination concentrates a spot of light at the center of the operating table. This concentration of light builds up shadowless illumina-

Fig. 11

tion of the order of 600 foot-candles on the table. It should be noted, in Fig. 10, that the center lenses are removed to show the position of the lamps and reflectors above the lens plates.

A rather unusual use of prismatic spread lens is illustrated in Figs. 11 and 12, which show the lighting of an art gallery by means of an artificial clerestory window. The problem was to project a band of light along the picture-hanging surface of the walls to create the illusion of daylight coming from the windows. The upper segment of each window is a spreading lens and behind each is a 1,000-watt spotlight projector directed toward the opposite wall. The lens spreads the beam into a band overlapping with the bands from adjacent units, thus effectively lighting the pictures. The entire window is made luminous by a number of small lamps within the metal housing which forms a backing for the window.

22. Special Requirements and Applications.—The various methods of lighting just discussed are applicable to all types of public and commercial buildings. Many other interesting examples might be described, yet enough has been said to indicate that the lighting engineer must be familiar with the general methods and be able to modify and adapt these to any particular case. To give more specific information on the requirements to be met in certain types of installations, several applications will be discussed briefly in the following paragraphs.

23. Church Lighting.—The lighting of churches should be dignified and impressive and without annoyance to comfortable vision. The character of lighting and the choice of equipment should conform in decorative design to the style of architecture and with the creed, in order that the final lighting effect may not only harmonize with the spirit of the interior but actually enhance it. A dimly lighted church interior is often regarded as conducive to a spirit of meditation and prayer, yet it is important that the lighting be such that the congregation be able to read with comfort. In modern churches it is the practice to provide a high standard of illumination sufficient for every use, and to install dimmers on a number of circuits and convenient switching arrangements in order to control the illumination to conform to the requirements of various parts of the ceremonies. The spirit of certain modern creeds, for example, appears to demand more general illumination, while other more severe

FIG. 12

creeds have become accustomed to lower standards and harsher effects. The dominant feeling of particular creeds should be studied and expressed by means of suitable lighting.

Congruity should be the aim of relating the lighting, architecture, and creed. Often the charm and expressiveness of tinted light may be effectively utilized. Many churches have lofty vaulted ceilings in dark tones, broken up by dark truss structure, requiring the use of direct-lighting luminaires. However, this does not mean that the light source cannot be of low brightness and comfortable. Large lantern-type luminaires with luminous art-glass panels may be designed around an efficient, high-powered, direct-lighting reflector. Such a unit may embrace all the decorative aspects and at the same time efficiently produce a high standard of illumination without glare.

Indirect lighting in its many forms is applicable in those churches which do not have dark ceilings. Architectural ornaments, domes, arches, statuary niches, and other features of design can be individually lighted in a manner that causes the chief lines and parts to be modeled or emphasized. Concealed lighting accomplishes this very well. Lamps may be concealed above the capital or behind moldings and large cornices wherever the architectural detail is worthy of attention.

It is generally desirable to light the chancel or altar considerably brighter than the general illumination in the church. This is accomplished by concealing suitable floodlights or window-type units behind the chancel arch, or projecting the light onto the altar from equipment concealed behind pillars or ornamental brackets. In church lighting the ceremonial uses of light should not be overlooked.

24. Church-Window Lighting.—Much of the charm and beauty of large stained-glass windows may be retained at night by illuminating these windows. Floodlights on the exterior will produce very pleasing effects for night services. On the other hand, where such windows are within view of people passing on the street, they may be illuminated at night by one or more floodlight projectors inside the church. The light transmitted through the colored glass causes the window to take on new life

and charm throughout the night when otherwise the beauty of these windows would be lost.

25. Library Lighting.—In the reading rooms of public libraries, at least 12, preferably 15, foot-candles should be provided. The illumination should be soft and well diffused from semi-indirect or totally indirect sources, which assures complete diffusion and elimination of sharp contrasts. Either a system of overhead equipment or lighting from concealed sources is particularly applicable, since illumination of this character produces an atmosphere of quiet so important in public reading rooms.

In some cases preference is expressed for moderate general illumination supplied by decorative ceiling luminaires, with a higher level of illumination for reading purposes supplied by individual desk lamps and portable lamps at the reading tables. Such a system furnishes an efficient means of providing a high level of illumination directly on the reading material, although unusual care must be taken in the design and installation of such local lighting system in order to avoid bad reflections from shiny paper.

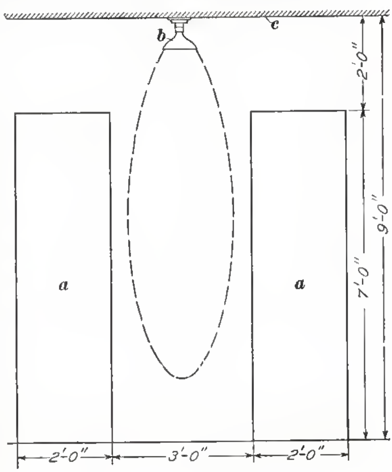


FIG. 13

26. Library Book Stacks.—A very important lighting problem in libraries is proper lighting for book stacks. Good service is dependent on quickly locating books, and much depends on whether the stacks are lighted adequately from top to bottom. Since the aisles are narrow, units with special light distribution are required. Special prismatic reflectors are available for this purpose. A satisfactory type of installation is shown in Fig. 13, which indicates a sectional elevation. The book stacks are shown at *a*, the reflector and lamp at *b*, and the ceiling at *c*. The

reflector is so designed as to diffuse the light between the stacks of books in the manner shown by the curved broken line.

27. Museum Lighting.—Such institutions owe their existence to their service in housing collections of art and historical objects. Their service as public institutions depends entirely on how well such objects can be seen, which in turn obviously depends on the lighting.

Art museums and galleries in which paintings are hung on the walls are best lighted by overhead sources, with the light directed predominantly to the walls. Many museums have avoided windows because, unless very high in the walls, their images are reflected from the glass or painted surfaces of the pictures into the eyes of the observers. One of the greatest problems, therefore, is proper direction of light so as to avoid obliteration of the display due to specular reflection.

Close cooperation between the architect and the lighting engineer is needed for the best lighting results. One example of this is shown in Figs. 14 and 15, where the architect made provision in the design of the ceiling to allow for projectors such as at *a* in Fig. 15, to be placed above a suspended ceiling *b*, with a band of stippled glass *c* inserted around the entire room. A section of the continuous sash which also runs around the room is shown at *d*. This method is inconspicuous and provides a high intensity on the walls without annoying reflections. Other types of museum lighting have been discussed.

The lighting of sculpture galleries introduces the problem of properly showing the modeled forms by means of light of proper intensity and direction in order that the object may have the character and expression which its creator intended. Indirect lighting or lighting from large skylights subdues all shadows; consequently, the appearance of all objects is flat and uninteresting. Such displays should therefore be lighted with predominance of light from one direction, for example, by directional lighting from a few high-powered projectors above a skylight or ceiling panel. Small objects can oftentimes be best displayed in individual alcoves, or niches, in which case the lighting can be accomplished by small lamps concealed within the alcove and

Fig. 14

so arranged that the direction of light will produce shadows to give whatever expression is desired.

In natural history museums, animal groups, insect collections, fossils, and the like are displayed in cases and the lighting must be studied with reference to each individual group. Oftentimes the lighting of large cases may be treated very similarly to show windows or show cases in stores. It is very difficult to avoid reflections of overhead lighting units in the glass of very low display cases. Inverted trough reflectors placed directly on top of such cases will oftentimes be found the most suitable solution.

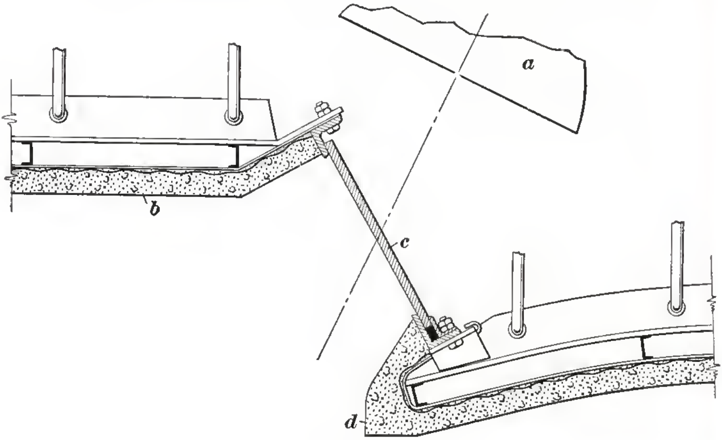


FIG. 15

28. Hospitals.—The lighting of hospital wards and private rooms presents no unusual problem, although in the past there have been some atrocious examples of lighting for these places. Inasmuch as the patient must perforce look upwards, the light sources should be of very low brightness, such as is provided by indirect lighting. A general illumination of 3 to 5 foot-candles is recommended. If some form of indirect lighting is used, preferably an urn-type wall unit located above the bed should be used, which will produce a minimum ceiling brightness over the area within the usual range of the patient's eyes.

Special reading lights over the head of each bed should be provided. For night illumination, use is made of wall panels

between beds. They are mounted low in the wall to furnish a very small amount of illumination on the floor, sufficient to enable the nurse or attendant to move about, yet not enough light to annoy patients who are sleeping.

In operating rooms the best conditions for close visual discrimination are required. General illumination of 10 to 15 foot-candles, with several hundred foot-candles on the operating table, is desirable. For hygienic reasons it is desirable to avoid use of exposed equipment and for that reason a system of the type described previously under the heading of *Prismatic-Lens Control* is particularly suitable. In all hospital operating rooms, emergency systems should be provided. This may consist of separate circuits with separate sources of energy supply.

29. Gymnasiums.—Gymnasiums require from 15 to 25 foot-candles for really satisfactory lighting for basketball, volley-ball, tennis, and similar games. In general, the requirement is simply that of providing this illumination without glare. Large diffusing units or large areas of glass panels should be used in order to produce the illumination level with low brightness sources.

A very interesting lighting application is that of under-water lighting for swimming pools as shown in Fig. 16. The method consists usually of 500-watt projectors of special water-tight construction set in recesses at intervals of about 15 to 20 feet along the sides of the pool. View (*a*) is a plan of the swimming pool, (*b*) a typical section, and views (*c*), (*d*), (*e*), and (*f*) represent different methods of installing the lighting units including the reflectors *r*. In each installation the water level is indicated at *w*. The recess containing the lighting unit is enclosed with a glass panel set flush with the wall. An advantage of under-water lighting is in the crystal-clear appearance of the water, and in the feature of safety because of the high visibility throughout the depth of the water.

30. Theater and Stage Lighting.—Theaters have furnished our principal examples of atmospheric lighting with elaborate systems of color coves, decorative and spectacular lighting effects. Little need be said of the general lighting, except to

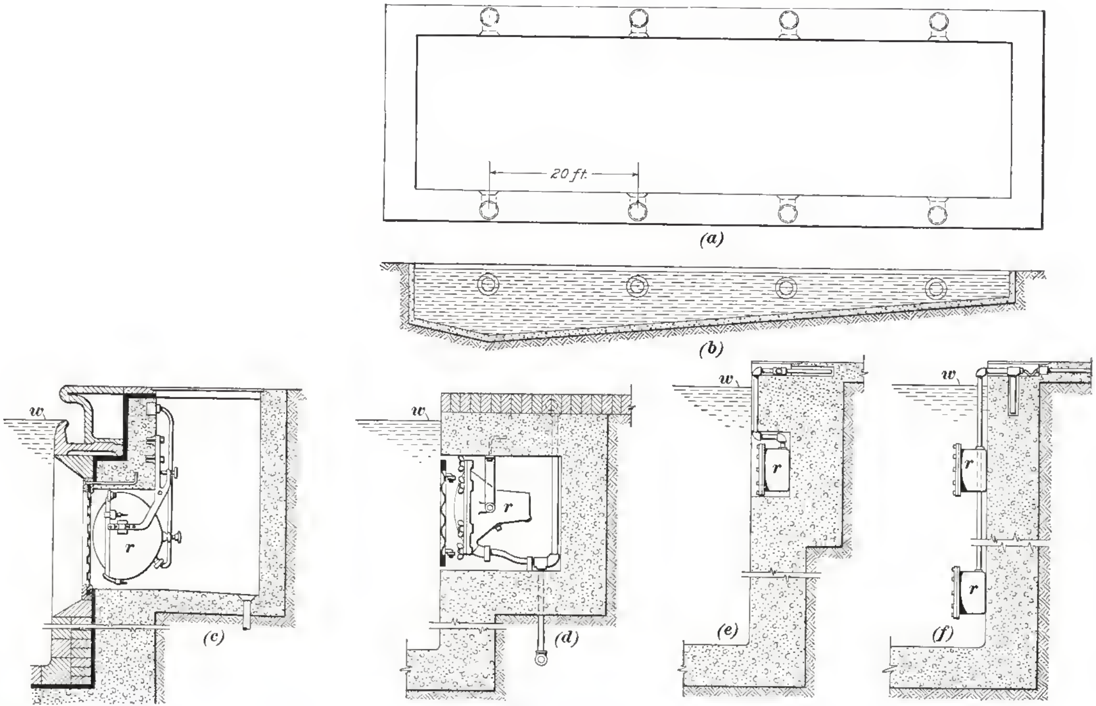


Fig. 16

say that theater owners are always alert to use all of the artifices that lighting engineers will put at their disposal in using light for beautiful and intriguing effects. Lighting for the stage presents certain requirements that will be discussed briefly.

A typical layout of a stage of medium size showing the various lighting facilities is indicated in Fig. 17. In conjunction with this, Tables IV and V show the lighting recommendations for various sizes of stages in terms of width of arch and the arch height. The function of the different equipments will be outlined.

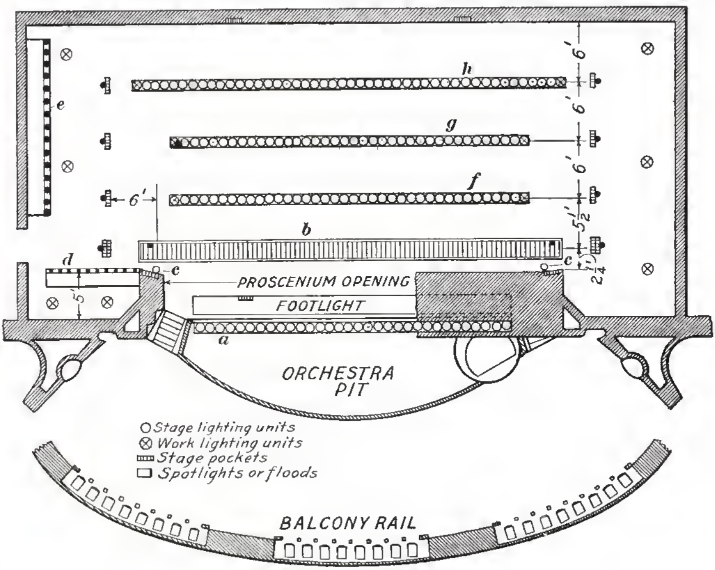


FIG. 17

31. Borderlights, indicated at *a*, Fig. 17, furnish the essential overhead illumination, and facilities should be provided for red, blue, green, and white color circuits. The units should light smoothly the complete expanse of back drop as well as provide highly directional light on the faces of actors so that facial expressions may be apparent. Best results are obtained with relatively narrow beams, such as are produced by reflectors of parabolic contours with polished or mirrored surfaces. To elimi-

TABLE IV

RECOMMENDED LIGHTING EQUIPMENT LENGTHS

Width of Proscenium Opening or Arch Feet	Length of Footlight and Proscenium Borderlight Feet	Length of Borderlights Feet	Length of Bridge and Cyclorama Borderlight Feet
20	15	18	20
30	24	28	32
40	33	38	44
50	42	48	54
60	51	58	66
75	66	73	80

TABLE V

RECOMMENDED WATTS PER FOOT FOR EACH COLOR

Arch Width Feet	Arch Height (Feet) Above Stage Floor					
	Application	20	25	30	40	50
20	Footlights	50–100				
	Borderlights	60–100				
	Cyclorama	75–165				
30	Footlights	50–100	50–125	75–125		
	Borderlights	60–100	60–100	75–150		
	Cyclorama	75–165	75–165	100–165		
40	Footlights	50–125	50–125	75–125	75–125	
	Borderlights	60–100	60–100	75–165	125–250	
	Cyclorama	75–165	75–165	100–165	125–250	
50	Footlights		75–125	75–125	75–125	
	Borderlights		60–100	75–165	125–250	
	Cyclorama		75–165	100–165	125–250	
60	Footlights			75–125	75–125	75–125
	Borderlights			75–165	125–250	125–250
	Cyclorama			100–165	125–250	125–250
75	Footlights					75–125
	Borderlights					125–250
	Cyclorama					125–250

NOTE.—The watts per foot values apply to each of the four colors—red, blue, green, and clear. Multiply these values by 4 to obtain the *total* watts per foot.

nate streaks and striations, the reflecting surface must be rippled or stippled, or a slightly diffusing coverplate may be used. For the higher levels of illumination required on large stages, borderlights are designed to accommodate 300-watt and 500-watt lamps spaced 10 to 12 inches apart. Additional borderlights are indicated at *f*, *g*, and *h*.

For smaller stages the reflector surface may be either polished or semi-mat. Oxidized aluminum gives fairly good results. Here 200-watt lamps, 8 to 10 inches apart, are satisfactory.

32. The *light bridge b*, Fig. 17, located close behind the proscenium arch replaces the borderlight often found in this location. The bridge offers a convenient place for spotlight and floodlight equipments. It is readily accessible and the units may be easily adjusted to provide local lighting of any desired color, on any part of the stage.

33. *Proscenium striplights* as at *c* consist of a vertical row of reflector units permanently placed just behind the jamb of the proscenium arch. They are hinged so that they may be directed to various parts of the stage to furnish side lighting of any color as a supplement to the overhead lighting. Proscenium striplights are similar to small border lights in that they are individual reflector units alined in a channel or hood.

34. The *proscenium lights* or *first borderlight* or *footlights* should be far enough forward to provide good overhead lighting for the apron. Footlights serve to light the stage floor adjacent to the apron, but when used alone they may produce unnatural effects and expressions because the light comes from below. For that reason, good lighting for this part of the stage requires overhead lighting to supplement the footlights. The latest type of footlights are of the unit reflector type of aluminum, chromium or similar materials.

35. In addition to the permanent equipments, a considerable number of *portable equipments* are needed. One or more spotlight towers placed on each side of the stage give great flexi-

bility of side lighting. Floodlight stands, with one or more wide angle floodlights, serve a similar purpose. *Portable striplights,* which may be laid on the floor or hung from scenery, serve special purposes, such as the lighting of doors and windows.

For all stages a seeming superabundance of extra outlets is a decided asset and results in future savings, besides offering increased flexibility and convenience in the operation of portable lighting equipment. Groups of extra outlets spaced about 6 feet apart should be placed on both sides of the stage as well as at the sides of the proscenium arch and along the back wall.

36. Effective lighting of both the house and the stage is dependent upon flexibility and simplicity of the *light control.* The switchboard, as at *d,* Fig. 17, should be of ample capacity and placed in the most advantageous position, and there should be plenty of room for operation and maintenance. When laying out a stage, a definite switchboard recommendation should be obtained so as to make ample provision for it in the original plans. Considerable progress may be expected in remote control of lighting by special systems which have already suggested many opportunities for advanced application of control devices.

37. Adequate provision should always be made for *utilitarian lighting* so that work may be carried on efficiently when the stage is not in use for performances. Sometimes borderlights are used for this purpose. This is a rather expensive procedure because such lights do not provide light where needed, without using excessive wattages. Properly placed work lights prove much more practical and satisfactory.

Work lights hung from the fly galleries and side walls provide the general utility illumination needed. These lights should be on special circuits. In addition, it is desirable to have local lighting of the switchboard, of the counterweight control indicated at *e,* Fig. 17, and the stage pockets, to be used during the presentations and while the stage is dark.

DUAL-PURPOSE LIGHTING

38. General Discussion.—It seems very likely, with the advent of simple and reliable sources of ultra-violet radiation such as the tungsten arc (Type S-1) and tungsten filament lamps with bulbs of special ultra-violet transmitting properties, that our lighting systems of the future will be designed with the double purpose of providing both illumination for vision, and short-wave radiation for health maintenance. A description of a dual-purpose lamp of this type is given in the lesson on *Electric Illuminants*.

At the present time a number of installations of this character are in service. Unquestionably the influence of such combined facilities cannot help but make itself felt in the benefits that will accrue to a nation of indoor workers, if the beneficial rays of sunshine are brought indoors as an integral part of the general illumination system.

It should be pointed out that the study of ultra-violet radiation is a science in itself and that much knowledge must yet be gained before the practice of dual-purpose lighting can be generally extended. For example new materials and new technique must be developed for effective control and utilization of ultra-violet radiation. Materials that are good reflectors of visible light may be worthless as reflectors of ultra-violet radiation. Metals, glass, plaster, and painted surfaces now effectively used as reflecting surfaces for lighting purposes, reflect very little ultra-violet radiation. This means a study of the properties of new materials or materials not now commonly used, in order to obtain suitable reflectors and suitable wall finishes which will conserve the ultra-violet radiation. From the promising aspect, however, in the development of reflecting equipment, interior finishes for rooms, and accessories that conserve the beneficial radiation, the practice of so-called dual-purpose lighting will, no doubt, be rapidly extended.

PHOTOFLASH LAMP

39. General Description.—A photoflash lamp has been developed which in shape and size is similar to a 100-watt incandescent lamp. The clear-glass bulb contains a quantity of very thin crumpled aluminum foil in an atmosphere of oxygen. A filament of 1.5 volts rating is mounted within the mass of foil and serves to start the flash. This filament is coated with a

FIG. 18

special chemical that helps to accelerate the flash and insure the operation of the lamp, even though the filament is not in contact with the foil.

40. Operation.—The photoflash lamp is designed to operate on voltages ranging from 1.5 volts to 125 volts, direct or alternating current. The amount of light given off by the flash, which lasts approximately $\frac{1}{50}$ of a second, depends on the burning of the foil in the bulb rather than the voltage used to start it. Although the lamp can be flashed from a single small flashlight cell, the use of a two-cell battery will insure more satisfactory

operation. Where it is necessary to operate several lamps simultaneously from batteries, two or more of the large dry cells should be used because the momentary current taken by the lamp amounts to several amperes, and the small flashlight cells might be of insufficient capacity.

In photographing large areas requiring the light from a number of lamps flashed simultaneously, a 115-volt lighting circuit is most desirable. The fusing of the circuit should provide for 1.5 to 2 amperes for each lamp to be flashed. A 15-lamp circuit should be fused for 20 to 30 amperes; a 20-lamp circuit for 30 to 40 amperes.

41. Equipment.—The photoflash lamp should be used with suitable control equipment to obtain its full advantages. Since the flash is entirely within the bulb, reflectors may be used to collect the light and redirect it into areas where it will be most useful. A hand unit for use where only one lamp is required is shown in Fig. 18. The lamp socket should be permanently attached to the reflector so that, with the lamp in the socket, the unit is instantly ready for use. The handle of the unit, containing the two flashlight cells, should be provided with a spring switch, which closes the circuit only while the switch button is being depressed.

Certain types of commercial and professional photography work require more than one lamp and reflector. Units may be designed so as to permit the reflectors to be mounted on tripods, hung on a cord, etc. A flexible cord with connectors at intervals of 6 to 8 feet can be used for connecting the individual reflectors to the supply line. A multiple wiring arrangement is recommended in preference to a series circuit.

EXTERIOR LIGHTING PRACTICE

Serial 2719 Edition 1

INTRODUCTION

1. Outdoor lighting holds a fascination and an appeal in its many forms and applications. Its effects are, in many cases, striking and spectacular and its benefits are increasingly important in this outdoor age.

It is a far cry from the torch bearers of ancient and medieval times to the freedom in outdoor night activities which is enjoyed today. Street lighting was one of the earliest applications of electric lighting, and was practically the only form of outdoor lighting for many years. It was long typified by the lonely arc lamp or a cluster of small carbon lamps at street corners. At the beginning of this century electric signs made their appearance. The first important example of floodlighting did not come until about 1915, when the coiled-filament, gas-filled incandescent lamp made the floodlight projector practicable.

Many factors have combined, during the past 10 years or more, to make outdoor lighting go forward with phenomenal strides. The greatly increased number of automobiles, accompanied by efforts toward the safety of street and highway traffic, made new standards of street lighting imperative, and dictated the development of elaborate traffic-signal systems. The automobile has fostered a new outdoor age. More people abroad at night stimulated and developed a new economic market for outdoor electrical advertising; likewise, floodlighting, decorative, and festival lighting were given impetus. This new mode of outdoor living has fostered renewed interest in outdoor sports and recreations, with a demand for adequate lighting in order that these sports may be indulged in during the leisure evening

hours. The inauguration of the night air mail introduced still another outdoor lighting problem, and opened up a vast new field for lighting technique and application.

2. Nearly all of the problems of outdoor lighting must be approached with the same fundamental principles as govern the lighting of interiors. The simplest concept is that of delivering lumens of light from one or more light sources to a given area. This concept must necessarily be modified to embrace the requirements of any particular application, but, in general, every illumination problem involves, fundamentally, the question of light-flux quantity and the area to be lighted.

When the electric arc was first introduced, it was the most powerful and brilliant light source that had ever been devised. In the absence of illumination units and convenient instruments of measurement, the idea developed of lighting entire cities by means of several of these arcs or miniature suns mounted on high towers; a number of installations of this sort were made. The futility of such a scheme is quite apparent now, when one considers the ratio or the lumen output of the early carbon arc to the area of even one city block. With an output of 2,000 lumens, for instance, spread over an area of 200,000 square feet, an average of only one one-hundredth of a foot-candle would have been produced, if there were 100 per cent. efficiency of equipment. Rough computations indicate that if all the power that it is now possible to generate from all of the steam and water-power sources of the world, were converted into light by the most efficient lamps now available, only an area less than 4 miles square could be lighted to a daylight standard of illumination.

An important distinction of outdoor lighting is the larger areas, gauged in thousands rather than hundreds of square feet, as compared with the areas commonly dealt with in interior rooms. The investment cost for equipment, the construction and maintenance costs, and the economical distribution of electrical energy are factors which enter prominently into the outdoor-lighting problem and which influence the actual lighting design much more than they do in interior-lighting installations.

Because of the higher ratio of investment costs to operating expenses for the outdoor lighting, it is desirable to operate the installation in such a way as to give the greatest practical efficiency of light production. Most of the outdoor applications use high-wattage lamps operating at high efficiency. Oftentimes where the burning hours per year are fairly short, as in certain outdoor-sports installations, it is most economical to burn lamps as much as 10 per cent. overvoltage, which increases the light delivered by about 38 per cent., thus making this gain in illumination without added investment. The slight increase in operating cost by virtue of the greater lamp efficiency, even at a considerable sacrifice of lamp life, shows an overall economy in many cases.

3. The principal difference between interior and exterior lighting lies in the means that must be employed in delivering the light to the area to be lighted. In interiors, the lighting equipment can usually be located directly above the area to be lighted, with the ceiling and walls aiding in the reflection and distribution of the light. In outdoor lighting, the light sources must, in a good many cases, be located outside the lighted area, perhaps some distance away. This requires that outdoor-lighting equipment be designed for accurate control and efficient performance. Many other complications are introduced in connection with the locations for such equipment as may be feasible. Hence, considerable judgment is required in the selection of suitable equipment to give the required distribution. This is particularly true in building floodlighting. For airport floodlighting and for most outdoor-sport applications, where the lighted area must be kept free from obstructions, high-powered projectors of special light-distribution characteristics are required.

In many outdoor applications, where the lighting is accomplished by large groups or batteries of high-powered projectors, the matter of extreme brightness of the light source is encountered. This oftentimes calls for considerable foresight and some ingenuity in the placement of the equipment to avoid serious glare as well as harsh and confusing shadows. Each application

calls for a special study of all the important factors that enter into the particular problem. Some of the applications of outdoor lighting are so relatively new that only guiding principles and trends of practice can be stated.

TYPES OF OUTDOOR LIGHTING

STREET AND HIGHWAY LIGHTING

4. General Discussion.—Electric street lighting was first introduced by arc lamps shortly before the incandescent lamp was invented. Not until the development of the gas-filled lamp in 1915 was street lighting by incandescent lamps seriously considered except in small towns and occasional uses where small lamps were suitable. Since that time, however, street-lighting practice has switched almost completely to the incandescent lamp, so that today, few, if any, new arc street-lighting systems are being installed. The reason for the change of practice lay largely in the greater simplicity, convenience, flexibility of control, and range of sizes, and the lower maintenance costs of the incandescent-lamp system.

Though street lighting antedates all of our other electric-lighting uses, it has proved one of the most difficult for which to draw up adequate specifications from the standpoint of illumination results. In the absence of accepted standards, many street-lighting systems have grown up piecemeal with little coordinated study or planning as extensions have been made. The result is that the majority of street-lighting systems in our cities are totally inadequate and lacking in many features of economy and effectiveness.

5. The Street-Lighting Problem.—Street lighting is one of the municipal services for the common welfare of the citizens. Considering such a fact, no city should be satisfied with any system which does not meet the two principal requirements stated in the following paragraphs.

First, street lighting should provide sufficient illumination to allow free use of the streets at night without undue hazard to vehicle or pedestrian traffic. Street lighting is inherently a service in safety on a par with police and fire protection.

Second, the system should enhance the appearance of the street both by night and by day. Since the lighting largely influences night impressions of a city, civic pride demands a system that will beautify, and assert civic progress.

The lighting engineer must keep in mind both of these major requirements, and work out the most effective plans consistent with the funds available for the purpose.

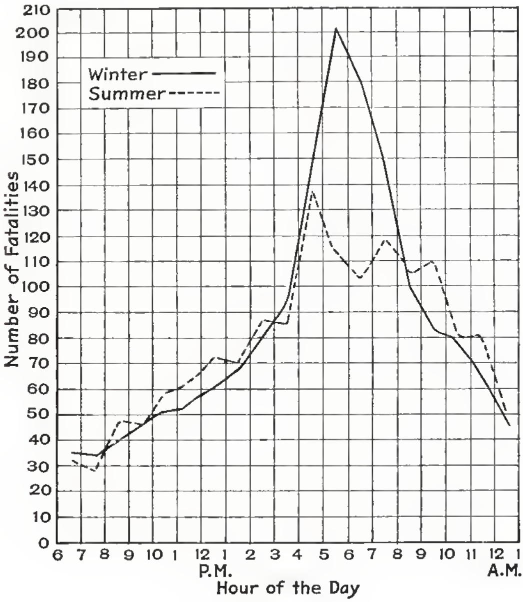


Fig. 1

6. Street Lighting and Its Public Benefits.—Adequate street lighting is a real contribution to the safety, comfort, and convenience of the citizens of a community. While there have been remarkable advances in street lighting, yet unfortunately, if the ever-growing automobile traffic conditions are considered, practice has lagged behind actual needs as far as safety is concerned.

In Fig. 1 are plotted statistics from the National Safety Council, showing the distribution of traffic accidents both in summer

and in winter. The figures indicated in such curves cover only four States. A study of these curves will show that during the hours of daylight (8 A. M. to late afternoon) the winter accidents average lower than summer accidents; similarly, after 9 P. M., when it is dark in both summer and winter, the same condition prevails, indicating that under like conditions of illumination, the summer and winter accident trend is quite similar. On the other hand, between 5 P. M. and 9 P. M. when it is daylight in summer and dark in winter, the winter accident curve shoots high above that for the summer. The conclusion of the National Safety Council, therefore, is that this increase in traffic fatalities, amounting to about 35 per cent., is due to the difference in illumination.

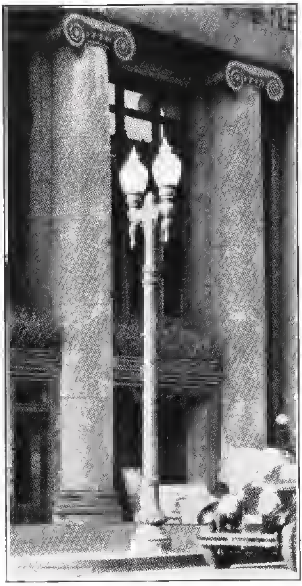
Adequate street lighting adds considerably to the freedom and peace of mind of individuals during night-time activities, because of less anxiety or fear of molestation. Fully 90 per cent. of the hold-ups, assaults, and burglaries take place after nightfall in poorly lighted places. It has often been stated that a street light is as good as a policeman, and police records have shown that a good system of lighting is a deterrent to crime. In one city where such an investigation was made, the installation of a high standard of street lighting is credited with having reduced crime 40 per cent. as compared to the number of crimes occurring on poorly lighted streets.

The influence of good lighting on reducing accidents and crime can be measured and evaluated. There are also many other benefits and conveniences that good street lighting makes possible, but that cannot be definitely measured. Among these might be mentioned the reading of street names and house numbers, printed directions and traffic signs. For the pedestrian there is the assurance that comes in recognizing acquaintances on the street, or seeing minor obstructions, and of avoiding missteps from uneven footing. From a business standpoint good street lighting enhances property values, and, in the case of stores, is so important in attracting trade, that it is rather common practice for merchant groups to unite in financing the installation of high-grade street lighting in their business district. Such lighting could be extended advantageously to other districts.

7. Working Toward a Comprehensive Plan.—In order that the complete street-lighting facilities of a city may be developed in a logical manner and present a unified appearance instead of a haphazard variety of equipments, it is recommended that each city undertake a complete plan of street-lighting development. This generally takes the form of zoning the streets according to several classifications, such as business districts, main and secondary thoroughfares, and residence streets, and determining the minimum illumination for each class according to the importance of the street as regards the amount of traffic each carries. This does not mean that the entire system need be installed all at once, but, when such a plan is developed, extensions may be made and better lighting provided as the budget permits, with the assurance that finally the entire city will be lighted, not only adequately, but with unity and harmony of design.

Manufacturers have made available various groups of equipment consisting of posts and globes of similar designs but in different heights, and with different lamp sizes suitable for the different illumination requirements of the various classes of streets.

8. Poles and Standards.—Since street lighting should be installed with regard for the appearance of the system, there has been a general adoption of some form of ornamental pole or standard. There are four common types of such poles or standards, classified as follows: (1) pressed steel; (2) cast iron; (3) tubular steel; (4) concrete. In addition, other types of fabricated-steel posts and wooden poles are in use, although in general they do not present so good an appearance. Each type of pole has certain characteristics of appearance, strength, ruggedness or cost which may recommend it for a particular class of installation. In Fig. 2 are shown street-lighting standards of modern type; views (*a*) and (*b*) being of the upright form and views (*c*) and (*d*) of the pendant form. In Fig. 3 the principal features of construction of a typical ornamental standard of pressed steel with a cast-iron base is illustrated; dimensions of a standard now in use in a parkway system are given. The cement foundation is indicated at *a*; the leads to



(a)

(b)

(c)

(d)

Fig. 2

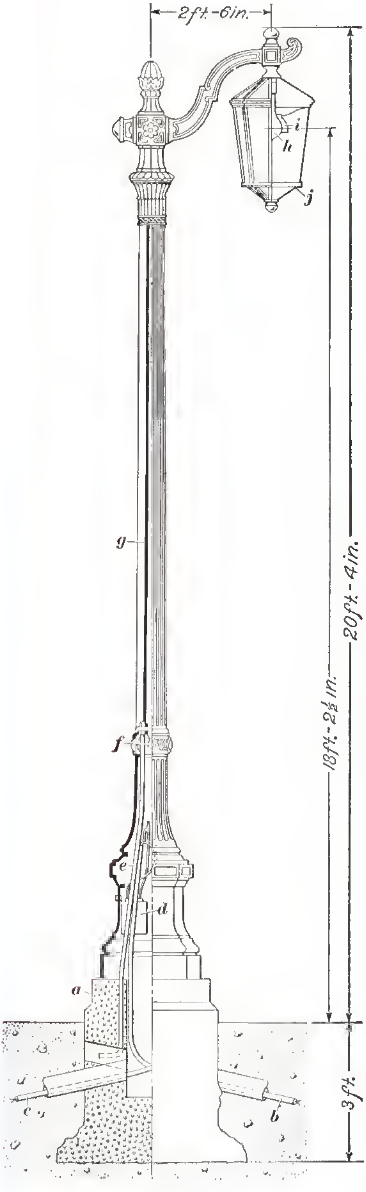


FIG. 3

the supply circuit at *b* and *c*; a two-coil transformer at *d*; a tie-rod at *e*; a low-candle-power lamp in a bull's-eye at *f*, which is a safety precaution designed to indicate the location of the standard in case of lamp failure in the main unit; a brace rod at *g*; the lamp at *h*; a prismatic reflector at *i*; and a lantern-type globe at *j*.

9. **Refracting and Diffusing Glassware.**—One of the advantages of the incandescent lamp in street lighting is the ease of control of the light distribution, by refracting and diffusing media. Many types of decorative units, of globe or of lantern type, either upright or pendant, are available. Likewise, various kinds of glass are used in the globes. Probably the most satisfactory type of glass is the pebbled or rippled surface with a light-opal flashing. Glass of this sort breaks up the light rays with some diffusion, yet retains a life and sparkle that is much desired; at the same time, globes made of this glass permit the use of refractors within the globe without much modification in the accurate control of the light distribution. A globe of this type, opened to

show the use and position of a prismatic refractor, is indicated in Fig. 4.

White diffusive glass is used to some extent in street-lighting globes with the advantage of more complete diffusion of the light and lower brightness; units of this character are suitable for certain locations in downtown districts, where they may be closely spaced and where it is advantageous to allow a considerable portion of the light to diffuse upwards on the building fronts.

Fig. 4

They are quite unsuitable for use in combination with the prismatic refractor. In Fig. 5 are shown two typical distribution curves of a medium alabaster, rippled-glass, upright globe; curve *A* indicating the distribution when no refractor is used, and curve *B*, the distribution when a band prismatic refractor is used. As indicated in Fig. 5, the band prismatic reflector is set to produce maximum candlepower at an angle of 75 degrees from the vertical. The purpose of the refractor in connection with a street light is to concentrate the light into a narrow zone of high candlepower which is directed at a considerable distance down the street.

10. Mounting Heights for Street Lamps.—As in interior lighting, the relation between the mounting height and the spacing of the lamps greatly influences the degree of uniformity of the illumination on the street. The actual ratio between the two is largely dependent on the distribution characteristics of the

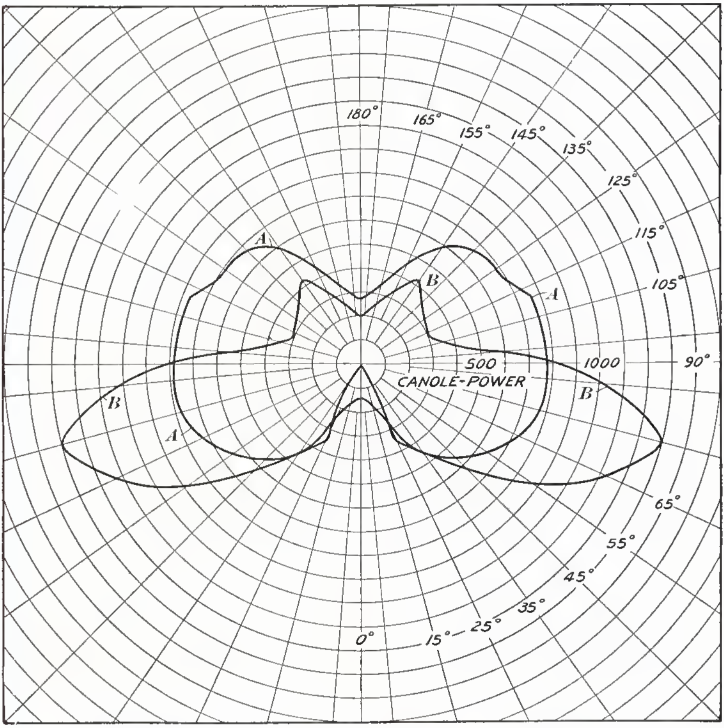


Fig. 5

unit. Simple diffusing units require much closer spacing than refractor units, which produce high-candlepower values slightly below the horizontal plane of the light source.

In street-lighting practice, the actual illumination values on the street are so low compared to general interior illumination, that visibility of objects by direct vision is only partially accomplished. A large measure of seeing is by silhouette, that is, the

object is seen in bulk with only the outline contrasted against a light background. This fact has considerable influence on the best location for the lighting units.

At best, it is difficult to avoid, entirely, glare from street-lighting units, because they must of necessity direct considerable light toward anyone on the street. The brightness of distant units is not seriously offensive from the standpoint of glare, although as one approaches a unit its brightness tends to become more glaring. The higher the units are mounted above the street level, the greater is the angle from the normal line of vision, and consequently the less is the glare likely to be experienced. By the same token, the larger the lamp expressed in lumens,

TABLE I

MOUNTING HEIGHTS FOR STREET LAMPS

Size of Lamp in Lumens*	Range in Feet Above Ground	
	Upright Type	Pendant Type
1,000 or less	12-14	14-16
2,500 to 6,000	13-15	16-25
6,000 to 15,000	15-22	18-25
15,000 to 45,000	20-30	22-30

*Note.—See lesson on *Illumination Principles.*

the higher the mounting height should be. Representative practice in the past as to mounting heights for various lamp sizes is indicated in Table I. While the recommended minimum height is 15 feet, recommended practice is in most cases higher, as stated later.

11. Location of Street Lamps.—Street lamps are commonly located in one of three positions with respect to the street:

(*a*) Over the center line of the street, the support being by means of span wires. This method results in the maximum number of lumens being delivered to the street surface. Such a system is, however, not particularly ornamental, and offers difficulty in replacing and cleaning lamps on congested thoroughfares.

(*b*) On bracket arms mounted on curb standards, but extending from 2 to 6 feet beyond the curb line. This scheme is nearly as effective as center mounting from the standpoint of lumens delivered on the street. In addition, it produces a sheen directly in the traffic lane, which aids in revealing people or objects by silhouette. The faces of the curbs are also well lighted when the units are beyond the curb line.

(*c*) Between the sidewalk and the curb at the top of ornamental posts. This brings the light source 2 to 3 feet inside the curb, improving considerably the lighting of the sidewalk but at a sacrifice of illumination on the road surface. For this reason, such a location is more applicable for business districts because of the greater number of pedestrians on the sidewalks, and, owing to the higher levels of illumination usually provided in such districts, pavement sheen becomes less of a factor in discerning objects.

12. Spacing and Arrangement Between Units.—It is generally good practice to make the spacing between units not more than eight times the mounting height. Spacings of this order provide acceptable uniformity of illumination between lights employing prismatic refractor units. Where refractor equipment is not used or where particularly good illumination is desired, it is common practice to space units much closer, the ratio of spacing to mounting height being perhaps only four to one. In a thoroughfare or a residence street, pendent equipment out over the roadway is more effective than upright units. Effectiveness is usually promoted by having lamps on both sides of the street, particularly where the street is wide. A staggered arrangement is advised for narrow streets. If practicable, lamps on curved roadways should be placed on the outside of the curve to indicate the roadway direction. A staggered system on such roads is generally undesirable. Adequate illumination should be assured at dead ends of streets or at offset streets.

13. Recommended Practice for Streets of Various Classes. The following standards, given under sections (*a*), (*b*), etc., for streets of various classes represent the general opinion of street-

lighting experts as to the minimum requirement for safety. Such experts also agree that considerably higher standards are entirely justified by the increased safety, effectiveness, and comfort afforded to those using the streets at night. Where such minimum standards are installed, provision should be made in the system to increase the standard when new conditions make it feasible. Street illumination is oftentimes expressed in terms of lamp lumens per linear foot of street. Practice includes a wide range, for example, from 10 to 100 lamp lumens per linear foot for highways, residence streets, etc., to 500 to 2,000 for *white way* lighting in business districts.

(*a*) *Light-traffic thoroughfares* (those that carry not more than 500 vehicles per hour in both directions) should have a staggered arrangement of lighting units, the units located on brackets extending beyond the curb and having a mounting height of not less than 18 feet; the spacing should not exceed 150 feet, and at this spacing and mounting height the lamp size should not be rated less than 4,000 lumens. The units should preferably be staggered on opposite sides of the street unless the width of the street is less than 25 feet. Mounting heights of 20 to 25 feet are recommended wherever practicable.

(*b*) *Medium-traffic thoroughfares* (those that carry a maximum of 800 to 1,200 vehicles per hour in both directions) require at least an 18-foot mounting of lighting units and a maximum spacing of 150 feet, but lamped with at least 10,000 lumens per pole. A staggered system with bracket-type units is recommended. The 18-foot mounting should be used only where trees or other conditions make this low mounting necessary; because of the larger lamps, a mounting height of 20 to 30 feet should be adopted where practicable.

(*c*) *Heavy-traffic thoroughfares* (those that carry a maximum of over 1,500 vehicles per hour in both directions) bear the same recommendations as for the medium-traffic thoroughfares, except that the 10,000-lumen units be spaced opposite instead of staggered, at a maximum of 150-foot spacing.

(*d*) *Business districts* should be classified as to vehicular traffic in the same manner as thoroughfares, and the same minimum standards should apply for each class. Retail-business

streets demand a high standard of lighting for the general attractiveness and business activity that well-lighted streets promote. Because of the greater pedestrian traffic, upright units back of the curb line are most satisfactory from the standpoint of general appearance of the street. One-, two-, or three-light standards are commonly employed.

(*e*) *Residence streets.* For residence-non-thoroughfare streets, the minimum height and spacing of lamps recommended is an 18-foot mounting height and no greater than 150-foot spacing if it can be avoided. Bracket-type units with not less than 2,500-lumen lamps should be used. Conditions may make necessary a lower height because of the prevalence of trees, and in this case the spacing between units should be correspondingly reduced, but in no case is it economical to use less than a 1,000-lumen lamp. At intersections of residence streets carrying only local traffic, not less than one 4,000-lumen or two 2,500-lumen lamps should be installed.

A digest of actual installations would reveal many examples of street lighting where the rating of the lamps or lighting units, etc., is much in excess of the minimum values suggested in the previous paragraphs. In addition to the urban requirements for street lighting, there has developed a similar need for lighting of intercity highways. The need for adequate highway lighting and the justification for it have been fully demonstrated in a number of installations now in operation. One deterrent to more rapid extension of highway lighting lies in the lack, in many states, of enabling legislation; that is, regularly constituted authority of State or County officers to authorize and approve expenditures for lighting systems along the highway. The economics of this subject and its relation to the rural electrification problem might be discussed at great length; however, for this lesson it is sufficient to give the minimum recommendations for this class of street lighting.

(*f*) *Highway lighting.* For pavement widths of 22 feet or less, the minimum recommendation is for 4,000-lumen lamps, mounted on brackets 28 feet or more in height and not more than 10 feet from a point over the middle of the highway, with a maximum spacing of 325 feet. When conditions do not permit

high mounting, a minimum of 22 feet and 2,500-lumen lamps at closer spacing may serve.

For broad highways carrying heavy traffic, the requirements are similar to city thoroughfares, suggesting a staggered arrangement of the units. The units should be mounted on brackets of sufficient length to bring the lamps out at least to the edge of the pavement. On curved highways, the units should be mounted out over the outside of the curve.

FLOODLIGHTING

PRINCIPLES AND APPLICATIONS

14. General Discussion and Classification.—The term floodlighting has come into common use more as a general designation of a field of lighting, rather than the application of specific units which are listed definitely as floodlighting equipment. So many and varied have become the outdoor lighting applications, that many new types of equipment have been developed to meet requirements for accurate control and various distributions of light needed to fit in with the available equipment locations.

A number of units used for floodlighting purposes are shown in Fig. 6. Typical enclosed floodlights commonly used are shown in views (*a*), (*b*), and (*c*). An ornamental type of street-lighting globe or lantern with internal mirrored reflector is indicated in Fig. 7 (*a*) ; a combination unit with a chromium concentrating reflector within a porcelain enameled reflecting hood, in view (*b*) ; and views (*c*) and (*d*) show large diffusing-type units of porcelain enamel or white-painted metal which have found considerable application where high directional candlepower is not essential. A lens-type unit which produces a flat, wide-angle beam, is shown in Fig. 8.

The first noteworthy use of floodlighting was for the exterior illumination of monumental structures where it was desirable to reveal their beauties after nightfall. A few notable examples, such as the Dime Savings Bank, Detroit, the Woolworth Building tower in New York, and the Statue of Liberty, were in evidence before the World war. During the war floodlighting was called into service, but the applications were largely confined to

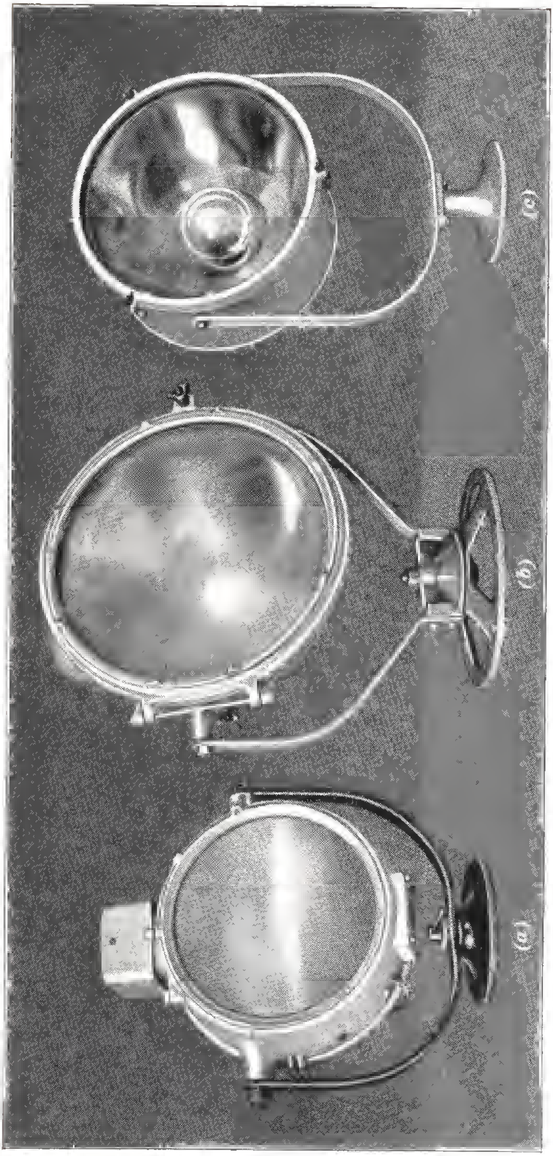
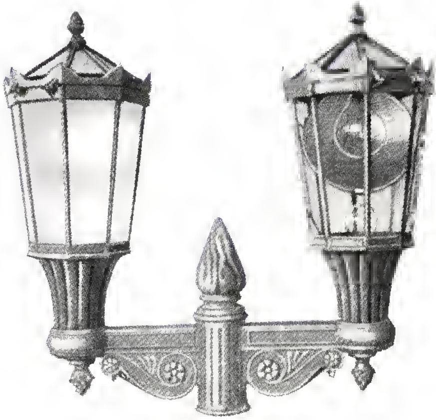


Fig. 6



(a)

(b)

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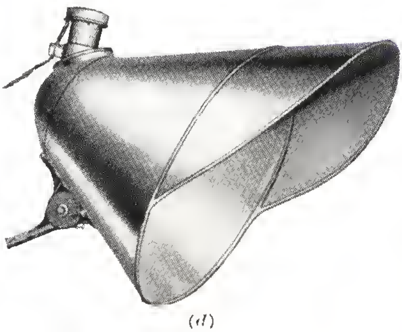


(d)

Fig. 7

utility installations where night lighting for shipbuilding and construction work proved its effectiveness in continuing outdoor work throughout a 24-hour period. Since the war, outdoor flood-lighting has had remarkable growth and the fields of application have been greatly extended.

The general field of outdoor floodlighting can be separated into three groups: (1) esthetic and advertising; (2) outdoor recreations; (3) utility. Each of these will be described briefly before discussing the general procedure in floodlighting calculations.

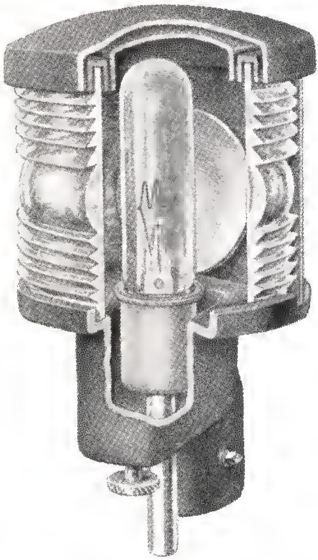


Fig. 8

15. Esthetic and Advertising Applications.—In the esthetic and advertising group of outdoor floodlighting are included such examples as are meant to appeal to our sense of beauty, or which compel attention and elicit favorable comment. Among installations of this character might be mentioned the following: imposing industrial and commercial buildings, façades, towers, columns, and other architectural features, monumental public buildings such as libraries, museums, capitol domes, statues, monuments, memorials, and fountains; natural wonders such as Niagara Falls, Natural Bridge, and Chimney Rock; natural beauties in public gardens and parks as well as beauty spots in private gardens and estates.

Each floodlighting installation in this class should be designed to produce a lighting effect that is in harmony with and enhances the appearance of the object lighted. In order to develop the most interesting aspect at night by means of esthetic floodlighting, the problem is almost entirely one of artistry in handling light to reveal some details, to subdue others, to emphasize mass

and architectural proportion by light and shadow, in silhouette or by direct illumination. Color may be introduced, and is being used more and more. Architects have accepted night lighting as a definite means of architectural expression, and the planning of large buildings is now greatly influenced by the night appearance with lighting effects worked out along with the building design.

Existing buildings that have lost their interest and charm through constant association may be made to live anew under the emphasis that well-planned illumination features can produce. Buildings of simple architectural treatment, or those designed for strictly utilitarian purposes, may have uniform illumination free from sharp shadows so that essentially daytime appearance is retained. Such a treatment emphasizes solidity, strength, and mass. The actual effect desired will be influenced by the character of the building and its surroundings. Buildings of classic design may be so lighted as to reveal the purity of line and composition, or, on the other hand, impressionistic effects may be striven for. For example, one large art museum was recently floodlighted to produce a moonlight effect with subdued directional lighting, allowing intervening trees to cast their shadows on the building.

Many modern buildings have set-back features with towers or ornamental balustrades or such design that they permit delicate shadings and shadow effects. In such instances color is generally introduced, and it is in this respect that architectural floodlighting will find its greatest field of development. While very beautiful and spectacular effects have been obtained by colored floodlighting with continually changing colors, there seems to be a general feeling that the use of color lighting demands a more subtle and delicate treatment than is usually provided with primary colors alone. In this connection there appears to be considerable opportunity for the lighting specialist with the necessary artistic qualifications.

16. In many cases, each section of a set-back building should be lighted with reasonable uniformity. To obtain such a result it is necessary to direct the larger part of the projector

beams to the top of the section, as the spill light from the units will assist materially in lighting the lower portion. Occasionally, where a building has a series of set-back sections, the upper portion of each section may be left comparatively dark so that it will stand out in marked contrast with the section above it. The result, while far from daytime appearance of the building, does give an interesting night effect.

Considering the building as a whole, no matter whether it is of the straight-side or set-back type, the illumination at the top should usually be two to four times as great as at the bottom of the building. Not only is more illumination necessary at the top to obtain the same apparent brightness over the whole building, but also from the appearance standpoint the greater apparent brightness is desirable at the top to give the impression of height, and to climax the effect.

Columns may be floodlighted in two ways: (*a*) the fronts of the columns may be lighted so that they stand out in contrast with the darkened recessed area, or (*b*) the fronts of the columns may be left in darkness to stand out in silhouette against the lighted background. Care must be taken to avoid a uniformity of illumination over both columns and background, as this destroys the form and depth of the columns and produces the effect of flatness.

In the case of statues and monuments, care must be taken to floodlight them in such a way that grotesqueness is avoided; that unnatural shadows and highlights do not produce an altered or distorted appearance.

In the lighting of natural beauties of gardens, landscaping, waterfalls, and similar places, a few specific suggestions can be made. Such applications may range from a single projector cleverly concealed to cast its colorful rays along a garden path or flowered bower, to such world-renowned illumination effects as are achieved in the ever-changing flow of colors obtained from the twenty-four, 125-ampere, arc searchlights, used to light Niagara Falls. It can truthfully be said that there are few beauties of nature that cannot, through the agency of light and color, be given a greater fascination and interest by night than by day. Every instance requires a detailed study of the conditions,

of the effects desired, and of the practical installation factors that must be considered.

17. Outdoor Recreations.—In the field of outdoor recreations, lighting applications have already been extended to include practically every popular sport. While not all of the outdoor recreations necessarily employ floodlighting equipment, they are all so closely allied in principle that they may well be covered in this lesson.

Night tennis, trap-shooting, boxing, horseshoe pitching, and many minor sports have been played at night for a number of years though not to any great extent. There appear to be tremendous possibilities in this field, if all of the cities were to follow the lead of a few which have lighted up all of the city parks and playgrounds for night sports and recreations. Night lighting for the major sports such as football, baseball, racing, and golf were represented by only a few experimental installations, and were not proved entirely feasible until about 1930. when a great number of installations of this character were made.

In recreational areas, objectionable glare must be guarded against by proper choice of equipment, of equipment locations, and of mounting heights that will remove the powerful light sources as far as practicable from the normal field of view. The object is to approach the uniformity of daylight illumination with few shadows. Modern practice and specific suggestions for the different sports lighting applications are taken up later.

18. Utility Floodlighting.—Utility-floodlighting applications include lighting for working areas, such as railroad yards, switch yards and docks, material storage yards, shipyards, building construction, parking areas, fire-fighting, and in fact any number of general conditions where work must be carried on at night. None of these applications requires particular elaboration beyond the fact that each should be studied to determine the visual requirements, and the lighting computed on the basis of these requirements. Airport lighting likewise falls in this classification but because of the extraordinary features encountered, this application warrants more details.

19. Foot-Candles Recommended for Outdoor Lighting. In Tables II, III, and IV are given the foot-candles recommended for various classes of outdoor-lighting applications. These values are given more as suggestions, since higher values will generally prove more satisfactory. For example, the recommended practice for football fields calls for 12 foot-candles, but at least one university uses as high as 50 foot-candles on the playing field.

TABLE II

FLOODLIGHTING BUILDINGS AND MONUMENTS

Representative Building Materials	Initial Reflection Factors* Per Cent.	Degree of Illumination According to Population		
		Over 50,000	50,000 to 5,000	Under 5,000
		Foot-Candles		
White terra cotta Cream terra cotta Light marble	60-80	10	8	6
Light-gray limestone Bedford limestone Buff limestone Smooth buff face brick	40-60	15	12	8
Briar Hill sandstone Smooth gray brick Medium gray limestone Common tan brick	20-40	20	15	10
Dark field gray brick Common red brick Brownstone	10-20	30	20	15

*NOTE.—Buildings composed of materials having a reflection factor less than about 20 per cent. cannot economically be floodlighted unless there is a large amount of light trim on the building.

20. Design Features of Floodlight Equipment.—Floodlighting equipment is characterized by the use of mirrored reflect-

ing surfaces to control the light accurately, and to redirect it into well-defined beams. Silvered glass, chromium, and polished

TABLE III

FLOODLIGHTING RECREATIONAL AREAS

Recreation	Foot-Candles Good Practice	Recreation	Foot-Candles Good Practice
Bathing beaches	1	Pageants	20
Baseball	20	Playgrounds	4
Football stadiums	12	Race tracks	6
Golf greens	10	Swimming pools	6
Ice skating	2	Toboggan slides	2
Miniature golf	10	Trap-shooting	15

aluminum are commonly used. Silvered glass has the advantage of greater reflecting efficiency over the metal reflectors. However, the use of any particular material is governed by efficiency,

TABLE IV

UTILITARIAN, PROTECTIVE, AND SPECIAL FLOODLIGHTING

Nature of Application	Foot-Candles
Construction work	6
Dredging	2
Flags, trees	25
Gasoline service station buildings and pumps.......	15
Yards and driveways...........................	4
Parking spaces	1
Quarries	4
Shipyards	6
Signs	30
Protective industrial	1
Smokestacks, water tanks	12
Stained-glass windows	30
Waterfalls	10

weight, breakage, and other factors that govern overall effectiveness.

The contour of the reflector and its relation to the light source determines the beam spread. Special floodlighting lamps with concentrated filaments are available for equipment requiring the highest degree of control; otherwise, standard lamps are used.

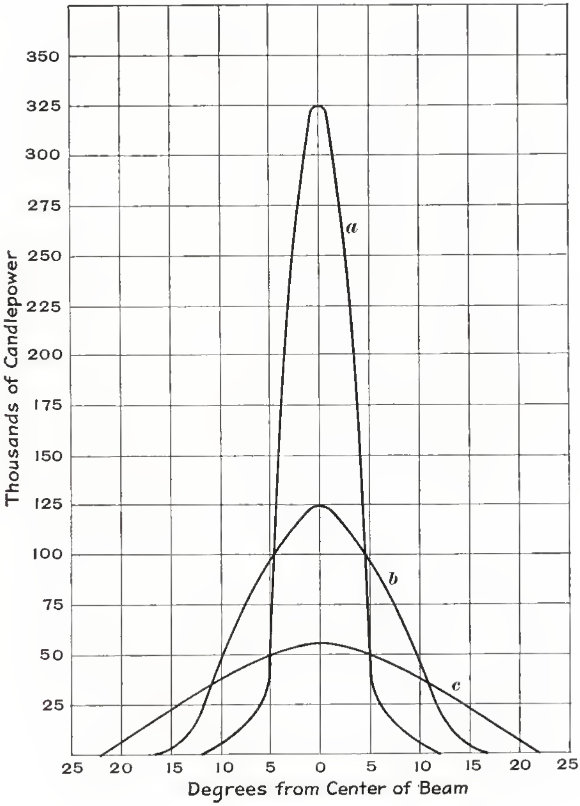


Fig. 9

Projectors are generally classified into three groups according to their beam spread, namely: (1) narrow, up to 15 degrees; (2) medium, 15 to 30 degrees; and (3) broad, above 30 degrees. Typical distribution curves of floodlight projectors are shown in Fig. 9. Curve *a* represents that due to a narrow-beam, curve *b* a medium-beam, and curve *c* a broad-beam projector. It will be

noted that the beam spread refers to the total beam spread in degrees; for example, the 10-degree beam has a spread of 5 degrees on each side of the center of the beam. Oftentimes there is no marked limit of the beam but for purposes of comparison of equipment, and for convenience in calculations, the total beam spread is taken between the limits where the candlepower has decreased to 10 per cent. of the maximum. Outside of these limits, the spill light is usually disregarded in calculations, although it is often depended upon for the illumination it produces close to the projectors. An example of this is in the lighting of football fields from projectors behind the grandstand, where the spill light is usually sufficient to furnish adequate illumination for the seating space.

21. Reflector Housings.—Copper, aluminum, and cadmium housings are replacing to a large extent the older cast-iron and sheet-steel housings. The former are light and durable, and resist corrosion. All floodlights should have convenient focusing mechanisms, permitting adjustments of the lamp position. These mechanisms should be of sturdy construction, simple design, and positive operation. Proper focusing is very essential to proper performance and to obtaining the desired beam spread, which is governed by the variation of the lamp from the focal position. Floodlight projectors are provided with swivel bases and with adjustable trunnions having adjusting screws so that the projectors can be aimed in any direction and locked firmly in position.

22. Cover Glasses.—The ordinary cover glass of a floodlight is of clear, smooth glass, and its primary purpose is to keep dust, dirt, and moisture out of the reflector. Whenever the beam is to be projected above the horizontal, as it is in a great many cases, the cover glass must be sufficiently heat-resisting to prevent cracking due to moisture, and care must be taken to insure a water-tight joint between the cover glass and the door. The cover glass also permits the incorporation of color, prisms, and diffusing mediums, with resulting modifications of the beam. For example, rectangular beams may be obtained by means of fluted or prismatic cover glasses. The efficiency of a floodlight

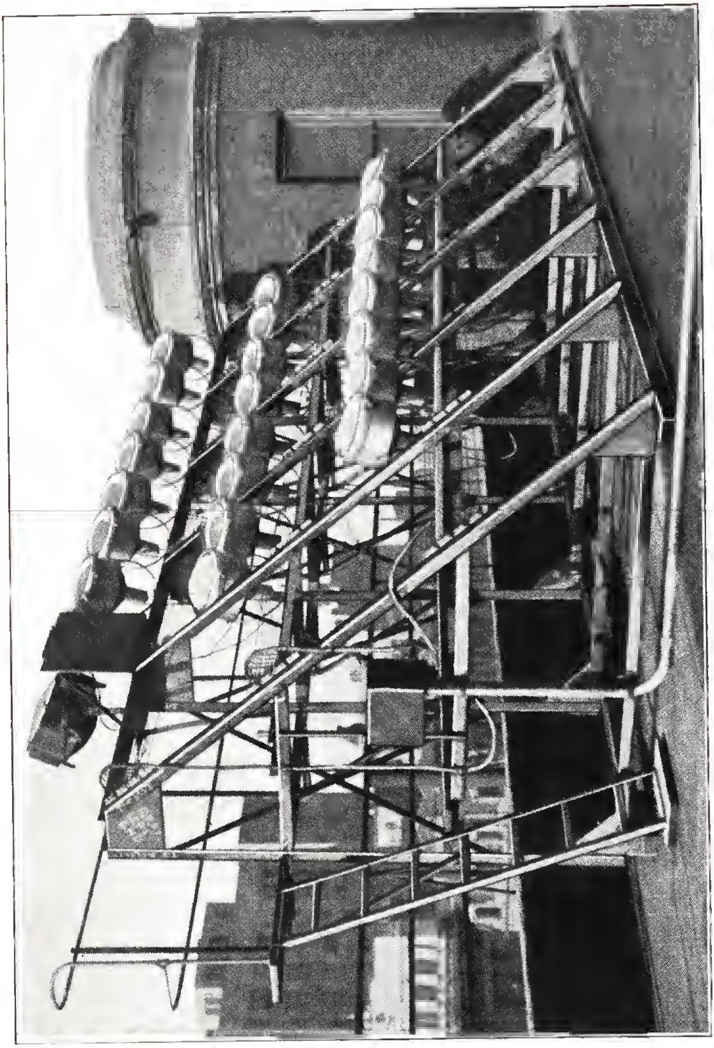


Fig. 10

Fig. 11

with a cover glass of the type mentioned, is usually about 10 per cent. less than when a clear cover glass is used.

23. Color Equipment.—Tinting and coloring of the light may be introduced by colored cover glasses, or by auxiliary glass color screens, or colored gelatines. Colored glass cover plates or auxiliary screens are of a permanent nature and should be used for permanent installations. Colored gelatines do not stand up well in service, so they are suitable only for temporary use. They have the advantage of a wide range of colors and tints.

The depth of coloring in color equipment should be such that the per cent. of transmitted light falls within the following values: amber, 40 to 60 per cent.; red, 15 to 20 per cent.; green, 5 to 10 per cent.; blue, 3 to 5 per cent. These figures give an indication of the additional wattage necessary to make up for the loss by absorption of the color screens. It is not necessary, however, to compensate completely for this absorption by increased wattage, as the effectiveness of color offsets to a large degree the reduction in illumination. The wattage as computed for clear light should be increased by about 50 per cent. when lighting with amber; it should be about doubled for red and tripled for green; and with blue it should be increased about five times.

24. Choice of Equipment and Its Location.—The choice of equipment as far as the beam characteristics are concerned depends largely upon the lighting effect desired, and on the distance away from the object. In many cases of building floodlighting, it has been possible to mount projectors on roofs across the street; many times such locations are not available and ornamental posts at the curb have been employed. Oftentimes projector equipment can be located on the ground and concealed from view behind shrubs and bushes. In other instances projectors have been located on marquees and window ledges. Set-back buildings offer particularly convenient locations for mounting reflectors behind the parapet. For lighting large outdoor areas, floodlights are generally mounted on tall fabricated steel towers. In Figs. 10, 11, and 12 are shown typical installations of floodlighting equipment for various applications. A few

Fig. 12

FIG. 13

examples of the effect produced by the floodlighting of buildings are shown in Fig. 13. The light from the units installed as in Fig. 10 is directed to light an adjacent building. In Fig. 11 the lighting units are located behind the parapet of the building which they illuminate.

TABLE V

A GUIDE TO THE SELECTION OF THE PROPER BEAM SPREAD

Representative Floodlighting Applications	Usual Distance Away	Proper Beam Spread
Buildings two or three stories high, lighted from marquees or posts at curb.......	10- 30 ft.	Broad
Buildings lighted from across the street or some distance away:		
Areas less than 3,000 square feet......	50-100 ft.	Medium
Areas more than 3,000 square feet......	50-100 ft.	Broad
Areas less than 3,000 square feet......	100-150 ft.	Narrow
Areas more than 3,000 square feet......	100-150 ft.	Medium
Areas less than 10,000 square feet.....	150-300 ft.	Narrow
Areas more than 10,000 square feet.....	150-300 ft.	Medium
Buildings of the set-back type:		
Set-backs one or two stories high......	On building	Broad or medium
Set-backs three or more stories high....	On building	Medium or narrow
Columns and ornaments.................	2- 10 ft.	Narrow
Construction work, parking spaces, gasoline stations, etc.	At edge	Broad
Football stadiums	50-100 ft.	Medium

25. Floodlighting Design Procedure.—In Tables II, III, and IV were given the foot-candles recommended for various applications. Since the foot-candle is equivalent to one lumen per square foot,* the general problem resolves itself into multiplication of the number of square feet of area by the foot-candles

*NOTE.—See lesson on *Illumination Principles.*

desired, to determine the total number of lumens that must be delivered to the lighted area. The effective distribution of these lumens is largely dependent upon the type of equipment and the proper directing of the light to insure the surface being uniformly covered.

TABLE VI

BEAM LUMENS OF TYPICAL FLOODLIGHTING UNITS

Beam Spread	Projectors Designed for Floodlight Lamps*		Projectors Designed for General-Service Lamps		
	Lamp Size in Watts	Average Beam Lumens	Lamp Size in Watts	Average Beam Lumens: Reflector Dia. 12″ to 16″	Average Beam Lumens: Reflector Dia. 13″ to 24″†
Narrow			300	1,400	
	250	1,100	500	2,500	
			750		5,500
	500	2,600	1,000		7,800
			1,500		10,500
Medium			300	1,700	
	250	1,150	500	3,000	
			750	4,900	6,000
	500	2,800	1,000	7,000	8,500
			1,500		12,500
Broad			300	1,900	
	250	1,200	500	3,400	
			750	5,200	6,200
	500	2,900	1,000	7,400	8,800
			1,500		13,000

*These lamps have concentrated filaments and can be burned in any position except within 45 degrees of the vertical, base up.

†These large units are recommended for long throws, or where the installation will be kept in operation for at least 5 years, or where there are unusually severe operating conditions.

In Table V is a guide to the selection of units of proper beam spread, and in Table VI data are given on the beam lumens of typical floodlighting units. Exact data for specific units are obtainable from floodlight manufacturers' catalogs. Knowing the total lumens required, the number of projectors required will be obtained by dividing the total lumens required by the beam lumens of a single projector. With allowance for depreciation,

the complete calculation can be expressed by the following formula:

$$\text{Number of projectors} = \frac{\text{area in sq. ft.} \times \text{foot-candles}}{0.7 \times \text{beam lumens}}$$

26. Check for Coverage.—In practical problems it is desirable to check all installations for uniform coverage. In checking results, the size of the spot or area covered effectively by each projector must be considered. This task is simplified by the use of tables that have been worked out to give the area covered by projectors of various beam spreads, mounted at different heights, and at different distances from the lighted surface. Sufficient allowance should be made for overlapping of the beams so that there is no spottiness, even through failure of one or two lamps in a group of projectors.

FLOODLIGHTING FOR OUTDOOR RECREATIONS

27. General Discussion.—The natural interest in outdoor recreations is national in scope, and the lighting of recreational areas for night play opens the field to the enjoyment of thousands who do not have the daytime leisure to attend or to take part in the sports. Attendance at night football and baseball games has doubled and tripled, not so much because of the increased interest in the games but because so many more people have the freedom to attend. One of the things that have delayed outdoor sports lighting has been the lack of good design to insure adequate levels of illumination and satisfactory results. It should be cautioned that, if an installation is worth considering, it deserves sufficient light, free from annoyances, so that the sport may be played or witnessed with the same degree of comfort and interest as in the daytime.

In most floodlighting applications when beauty and decoration are the essential factors, each individual application must be studied for the most desirable effects, and each is different. In sports lighting, on the other hand, the areas are fairly well defined, and the requirements of each can be determined and definite recommendations given. While it is impracticable here to include all outdoor-sports applications, the more important ones will be discussed.

28. General Requirements.—For outdoor sports and recreational areas, the lighting should be substantially uniform, with a minimum of glare. This is oftentimes difficult to accomplish unless considerable freedom is allowed in the location of equipment and in the height at which the units are mounted. When there are few restrictions on the location, equipment can usually be chosen with sufficiently accurate control, and by proper aiming of the projectors the lights need not be uncomfortable or glaring. In order to obtain such results it may sometimes be necessary to use spill rings and metal shields. Spill rings consist of a series of flat metal bands arranged in concentric circles, an inch or so apart, and attached to the front of the projector. Metal shields of suitable contour can be used to advantage to confine the light to an exact area, or to shield otherwise glaring units from view.

For many sports, such as tennis, racing, hockey, miniature golf, swimming, bowling, and shuffle board, the lighting problems are quite similar to those of indoor lighting. For these sports, overhead units mounted on poles with brackets or suspended from messenger cable are most satisfactory. However, the use of floodlight projectors is equally applicable and oftentimes necessary under certain conditions of installation.

In other sports, such as football, baseball, golf, trap-shooting, and the like, where the playing area must be kept free from obstructions, projection from a distance is required. Also, there must be considerable light directed upwards so that the ball or other object of play may be seen and gauged throughout its entire flight. It is not possible to show all the schemes used for lighting of the many sports, but those discussed will indicate the general considerations involved.

29. Tennis Courts.—Tennis requires quick and accurate vision with a high standard of uniform illumination so that the position and velocity of the ball may be accurately judged. The lighting units must be so placed that no glare is experienced in serving the ball or when looking up to follow highly lofted balls. In Fig. 14 is shown the lighting equipment for a group of courts with the usual dimensions. Instead of the poles and

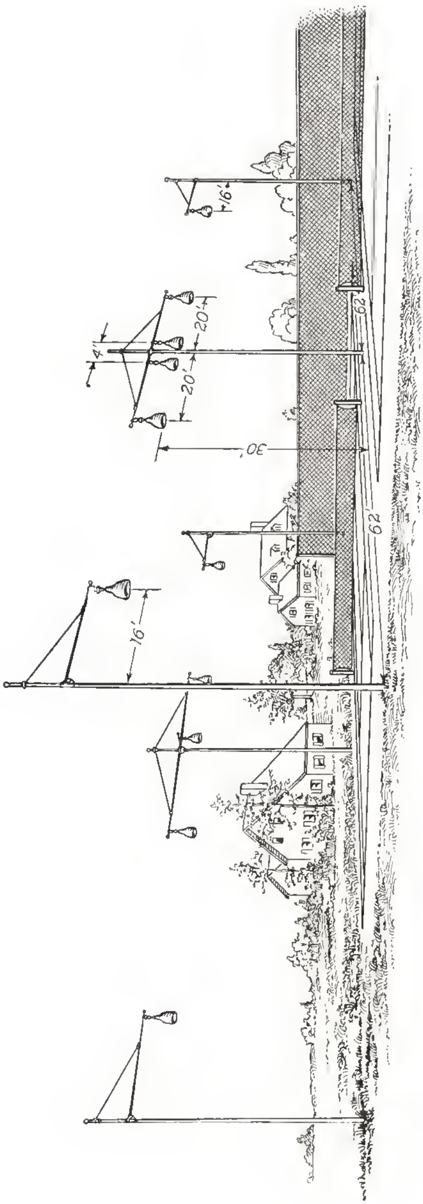


Fig. 14

brackets, the units may be suspended, with approximately the same layout, from steel cable stretched between poles located at the ends of the courts.

30. Miniature Golf and Putting Greens.—The lighting requirements for miniature golf and putting greens are not rigid, although for the most enjoyable play, the area should be well-lighted with little glare or harsh shadows. A number of schemes have been used, but, from a lighting standpoint alone, probably the most satisfactory system is by suspending standard RLM, or deep-bowl, reflectors overhead on messenger cable. Five-hundred-watt lamps on 25-foot centers, mounted 25 feet high, give very satisfactory lighting. Where lower mounting is used, close spacing is necessary. The higher mounting is recommended to minimize the possibility of glare and to avoid the annoyance from insects and flying bugs which often swarm around lighting units.

Other lighting that might be suggested is by floodlighting units mounted on poles at the boundaries of the playing area. In some cases, where general appearance was a matter of concern, ornamental globes fitted with floodlighting reflectors inside have been used. Unless mounted very high, it is usually somewhat more difficult to avoid glare and harsh shadows from floodlighting projectors than from overhead suspended units. Where the area is small, very satisfactory results have been achieved by the use of several light steel poles with reflector units mounted on short brackets about 40 feet high; in these installations, bowl reflectors of aluminum or porcelain enameled steel using four 1,000-watt lamps per pole will light an area about 80 feet square.

31. Roque, Croquet, Bowling-on-the-Green, Hockey Rinks. Sports like hockey, etc., are generally played on a well-defined area and the lighting requirements are not severe. Here again a system of overhead units suspended on cable above the playing area is most satisfactory. In general, the spacing for good uniformity should not greatly exceed the mounting height. From six to ten foot-candles will provide excellent lighting.

Where overhead equipment is not desired, a system of side lighting by angle reflectors, or floodlights mounted on poles

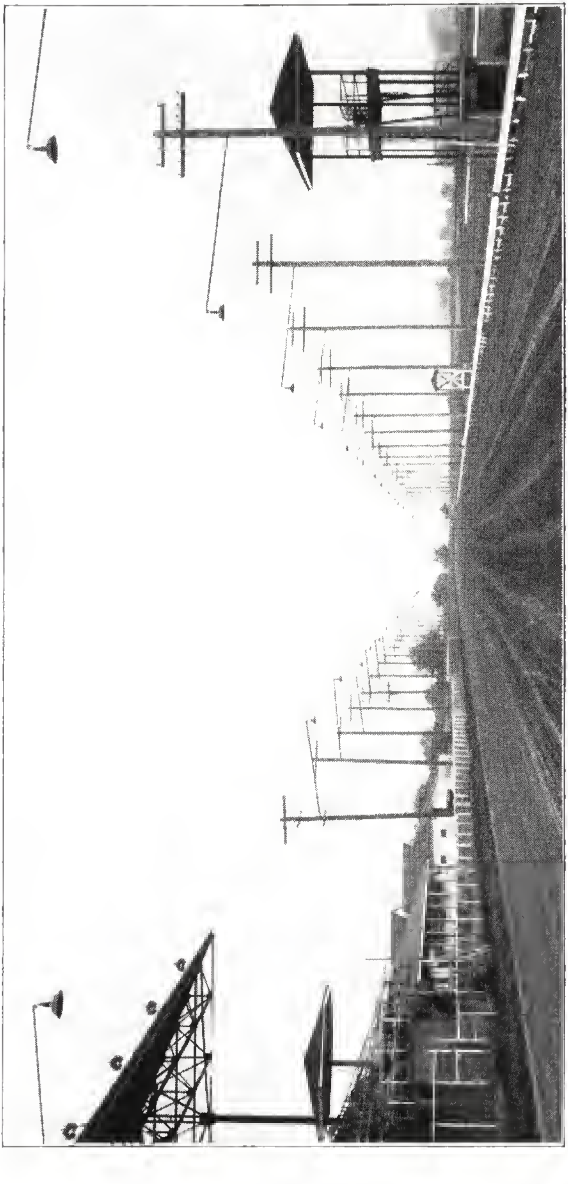


Fig. 15

from 20 to 30 feet high, can be used. In estimating the number and wattage of the units, the first step always is to determine the total lumens that must be delivered. Then multiply this figure by the probable utilization factor to arrive at the total aggregate lumen output it is necessary to provide.

32. Race Tracks.—Modern systems of night illumination for race tracks have proved a boon to the commercial success of horse racing, because of the greater number of interested people who can attend during the leisure evening hours. Early attempts at night racing did not prove particularly successful because of the lack of adequate light and proper distribution. In Fig. 15 is shown a day view of a race track, indicating the spacing and arrangement of the lamps used at night. Fig. 16 is a night view of such a race track on which an average illumination of more than six foot-candles is obtained.

Fifteen-hundred-watt lamps in RLM reflectors should be mounted at a height of about 30 feet and placed 50 feet apart on 12- to 16-foot mast arms on the inside of the track. On the home stretch, where the greatest interest lies, units should be placed on both sides of the track. This will provide a greater intensity and better distribution. In front of the grandstand, where poles would interfere with vision, broad-beam floodlight projectors mounted on the roof and aimed at the track are generally employed.

In most cases it will be found best to use two 750-watt units instead of a single 1,500-watt unit on the back stretch, the first unit being placed 4 feet and the second 16 feet from the inside of the track, both units suspended from the same bracket. Otherwise, it may be difficult to follow a horse close to the inside rail, since a single unit 12 to 16 feet out from the rail would not light the side of the horse toward the grandstand.

33. Baseball Fields.—Many league baseball fields are now illuminated and used regularly for night play. The first large installation at Des Moines, Iowa, in May, 1930, demonstrated the feasibility and commercial success of night baseball, after which the idea quickly spread throughout the country.

Fig. 16

The requirements for baseball fields are rather severe, since the problem is to light a large ground area fairly evenly and also to provide equally good lighting in the air. There must not be harsh shadows or any disturbing glare from any position on the playing field or from the stands. Installations of 15 foot-candles have been successful, but illumination levels of 25 foot-candles or more are certain to be much more satisfactory. A minimum of about 175 kilowatts is required to light a baseball field.

In Fig. 17 is shown a night view of a baseball installation. This view shows four of the six floodlighting towers employed, the other two being farther along the first- and third-base lines. These towers are 90 feet high and, in general, from 25 to 30 units are mounted on each tower with the reflectors directed at various angles. Both floodlight projectors and large open-type angle reflectors have been used with success. The higher the mounting the better, as this gets the light sources farther above the range of vision and reduces the likelihood of glare. The units should have a large shielding angle, or be so directed that it would seldom be necessary for a player to look directly into the main beam. For certain units, spill rings and glare shields may be used to protect against glare. There should be a cross-direction of light at every point on the field to avoid dense shadows.

34. Football Fields.—The lighting of football fields is less complicated than that of baseball fields; the ball is larger and the velocity less and the general direction of play is along one line. Two systems of lighting such fields have been employed. In one system, floodlights are mounted on 90-foot poles along the sides near the edge of the playing field, four to six poles being on each side. Such a system has commonly employed large open-type reflectors accommodating one, two, or three 1,500-watt lamps each. The aggregate wattage for all the lights varies from 50 to 100 kilowatts. Such a system will provide from 6 to 10 foot-candles on the field.

An alternate system recommended for the better class of installation uses floodlight projectors mounted on towers behind

Fig. 17

the stands. This has the advantage of eliminating poles between the spectators and the play.

In all cases the floodlights should be aimed sharply within the boundaries of the field, and with definite cut-off to avoid distressing glare to spectators in the opposite stands. Care must be taken that there is enough upward light provided, so that high punts may be followed and accurately gauged.

A system producing a high foot-candle illumination is that installed at the University of Detroit, a general plan of which is shown in Fig. 18 and a wiring diagram in Fig. 19. This system employs 320 kilowatts and was designed to produce 50 foot-candles on the playing field. On each of the four corner towers *A*, *B*, *C*, and *D*, Fig. 18, are located four 10-kilowatt lamps in special reflectors. This installation, however, is somewhat experimental in so far as the use of the large 10-kilowatt lamps for this kind of service is concerned. Their use cannot be fully recommended until more complete data are available on both lamps and equipment performance to meet the requirements of satisfactory and efficient service. Each of the side towers *E* and *F* at the center line of the field carries four large reflector units, each one of which is fitted with twenty 1,000-watt lamps. At the base of each of the towers *A*, *B*, *C*, and *D* is located a 50-kilovolt-ampere transformer designed for a voltage of 440-220-110 volts. Three two-wire No. 4/o Parkway cables *g* are run underground from *A* to *D*, and two-wire No. 4/o Parkway cables *h* and *i* from *A* to *B* and *C* to *D*. The underground three-phase primary supply line is shown at *j*; three 150-kilovolt-ampere, three-phase transformer secondaries rated at 460, at *k*; a three 400-ampere, 500-volt, two-pole fused safety switch, a current transformer, and a 600-ampere, 500 volt, three-pole fused switch at *l*. Five two-wire No. 4/o Parkway underground cables are indicated at *m*. The scoreboard is indicated at *n*.

In Fig. 19, the transformers at the bases of the four towers *A*, *B*, *C*, and *D* are indicated at *1*, *2*, *3*, and *4*, and the four 10-kilowatt lamps of such towers at *5*, *6*, *7*, and *8*. The four 20-kilowatt light units of towers *E* and *F* are indicated at *9* and *10*. The three-phase primary supply line is shown at *j*; three 150-kilovolt-ampere transformers at *k*, producing a 460-volt sec-

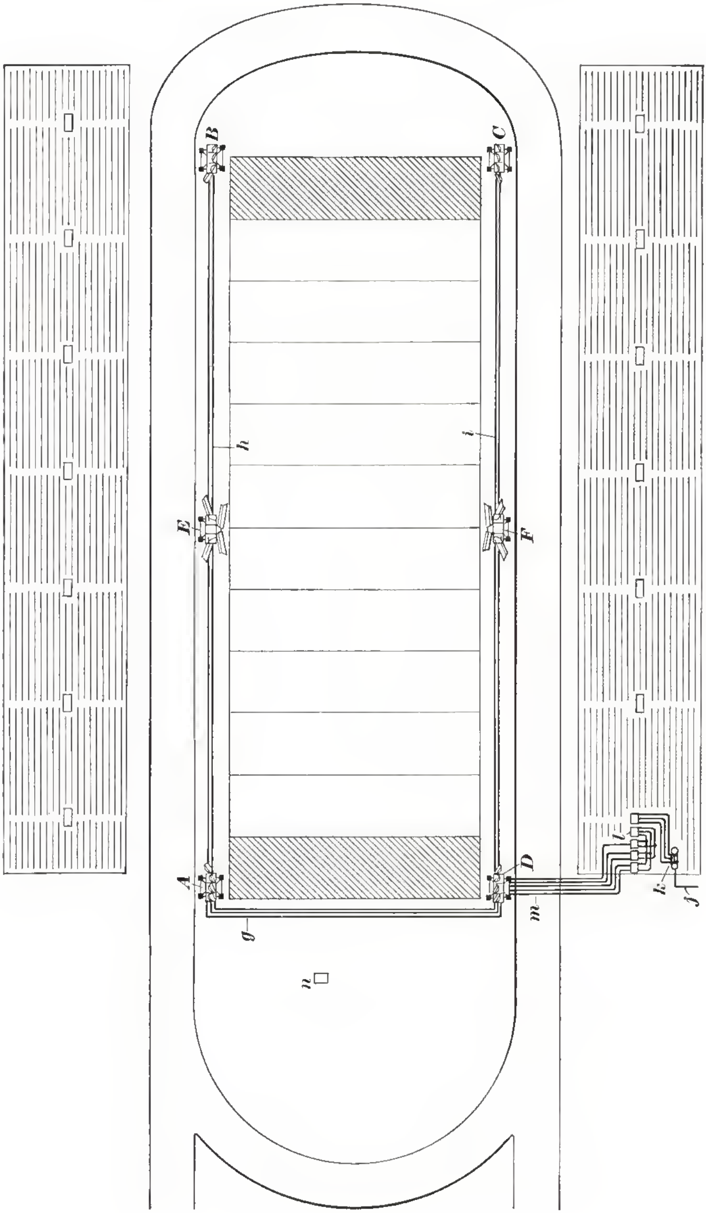


Fig. 18

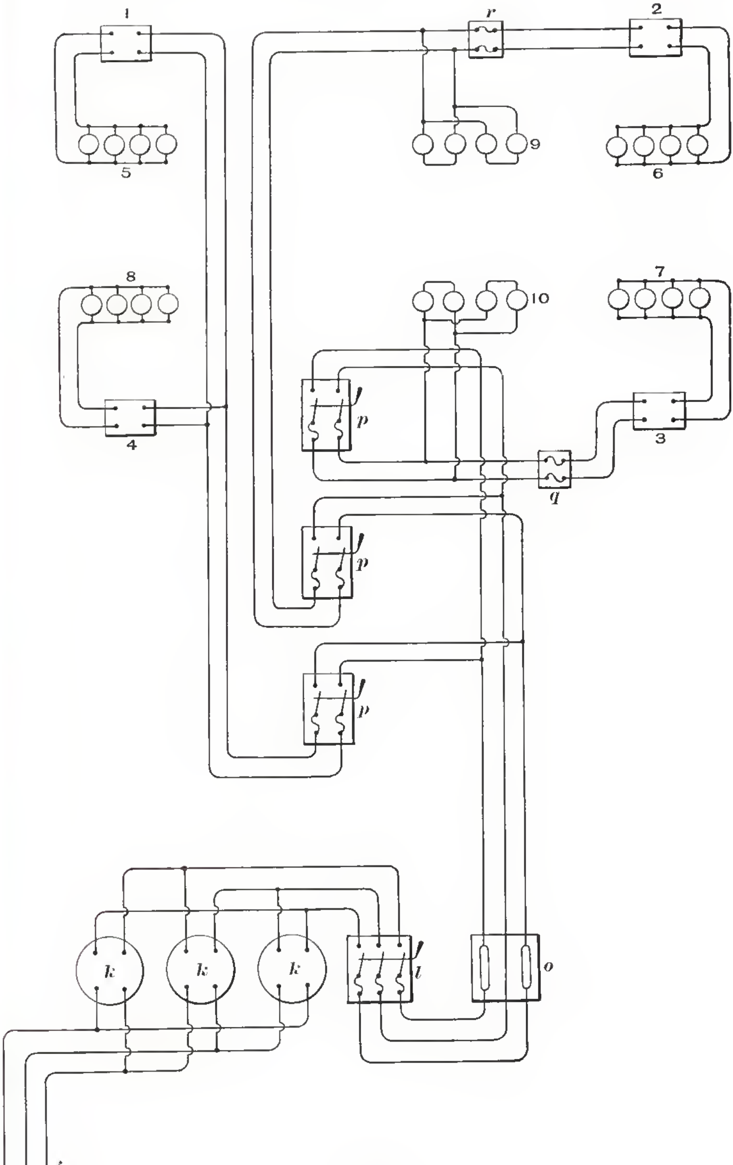


FIG. 19

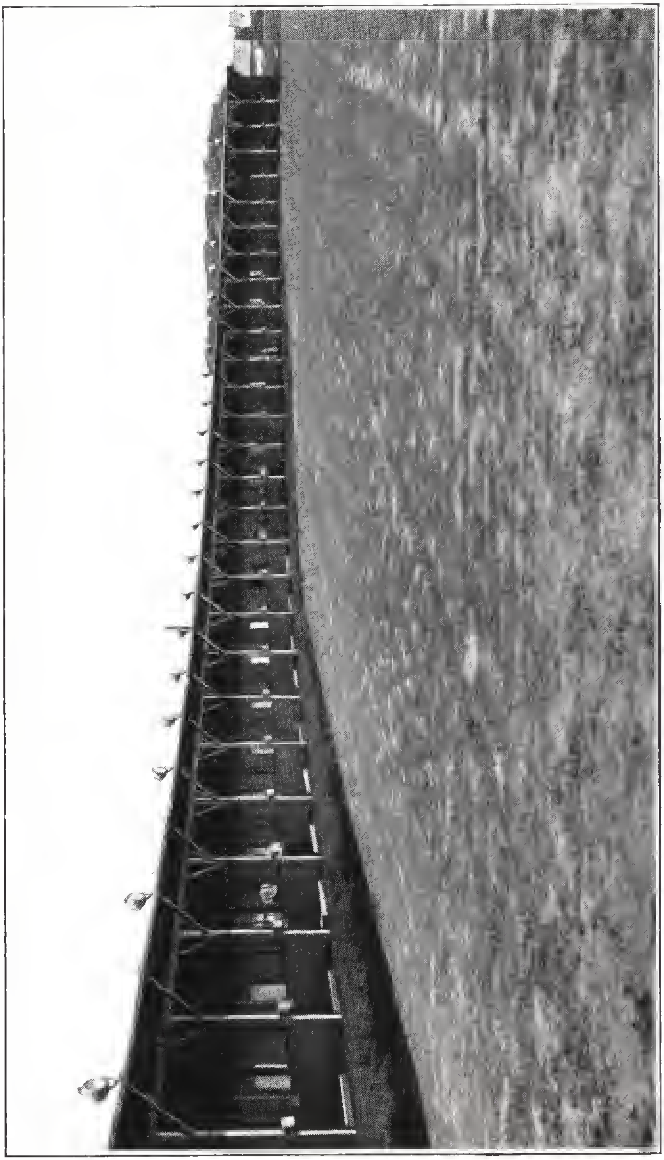


Fig. 20

ondary; a 600-ampere, 500-volt, three-pole fused safety switch at *l*; a current transformer for the power meter (not shown) at *o*; 400-ampere, 500-volt, two-pole fused safety switches at *p*; and fuse blocks at *q* and *r*.

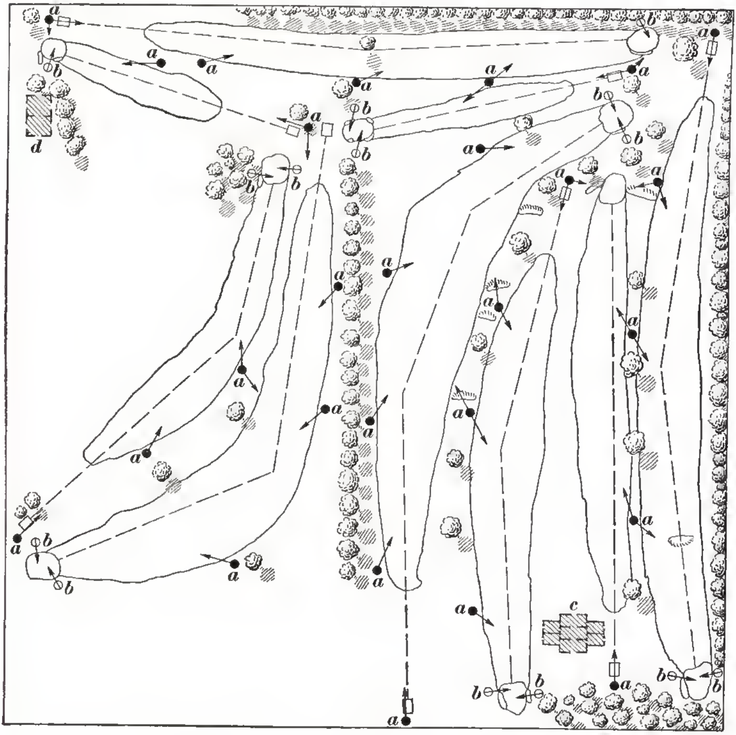


FIG. 21

35. Golf Practice Courses.—Many golf driving courses have been lighted, and this floodlighting application presents no unusual problem. Floodlights mounted overhead above the tees, either on poles or on the roof of covered tees, and directed toward the fairway, serve satisfactorily. For the usual areas, twenty to twenty-five 1,000-watt projectors are necessary for good coverage and adequate illumination. A view of an installation of this kind is shown in Fig. 20. Five or six of the projectors should be of the narrow beam, high-candlepower type to cover

the rear portion of the range so that long drives of the order of 200 to 250 yards may be followed throughout their flight, and that targets or greens at these distances will appear to be as well-lighted as those close by.

36. Major Golf Courses.—Lighting for major nine- and eighteen-hole golf courses presents a rather difficult problem, and one to which no standard recommendations will apply. There are many variables, such as the contour and width of the

TABLE VII

KILOWATTS REQUIRED FOR GOLF COURSE

Kw.	Hole	Yards	Par
28	1	478	5
28	2	445	4
22	3	337	4
25	4	372	4
35	5	544	5
16	6	196	3
29	7	432	4
26	8	316	4
16	9	214	3
225		3,334	36

fairways, location of traps, length of holes, adjoining fairways and tees, as well as the presence of trees, all of which must be considered. Such matters as electrical distribution, location of poles, and maintenance introduce complications. The avoidance of glare and the elimination of shadows are two of the most important factors from an illumination standpoint. In spite of these limitations and handicaps, golf courses have been lighted for satisfactory night play.

High mounting of the lights will help to reduce glare, although considerable judgment is necessary in choosing locations for equipment. From 5 to 10 kilowatts are required for each 100 yards of fairway, with additional light provided on the greens. One pole should be directly behind each tee and succeeding poles

down the fairway should not be more than 100 yards apart. Hills and depressions along the way may dictate a closer spacing. A typical layout for a nine-hole golf course is shown in Fig. 21. The lighting units indicated by the letter *a* consist of floodlighting projectors with clear glass doors and 1,000-watt Mazda lamps. The units indicated by the letter *b* consist of floodlighting projectors with heavy stippled glass doors and 1,000-watt Mazda lamps. Buildings are represented at *c* and *d*. The data given in Table VII apply to the installation shown in Fig. 21. The first column of the table shows the kilowatt installation corresponding to the lighting units installed at the various holes of the course.

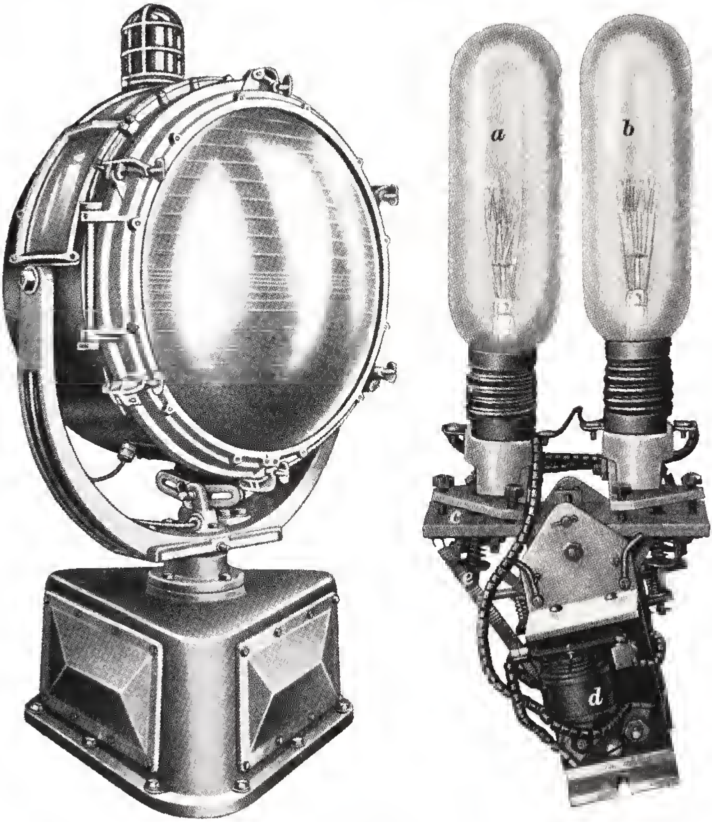
FLOODLIGHTING FOR AIRWAYS AND AIRPORTS

37. Provision for Lighted Airways.—The lighting of airways and airports is of special importance. This is due partly because of the recent development of aviation and the popular interest in it. In addition, however, such importance is due to the part that light plays in the full success of the aviation industry and the great possibilities for exceptional development in extending lighted airways and airport lighting facilities.

An *airway* is considered as a strip 5 miles wide leading from one airport to another. The establishment and administration of civil airways in the United States is in the charge of the Director of Aeronautics, Department of Commerce. He is responsible for beacons, intermediate landing fields, signals, radio, and general navigation facilities for the safe operation of aircraft over such routes. Under the provision of the Air Commerce Act of 1926, lighted air routes have been rapidly extended.

The principal feature of lighted airways is the installation of beacons located approximately every 10 miles along the route. A typical airway beacon is shown in Fig. 22 (*a*). Beacons consist of 24-inch, 1,000-watt, two million candlepower projectors revolving at 6 r. p. m. Projectors are mounted on the tower platform about 50 feet high, and each main projector is equipped with an automatic lamp changer, as shown in view (*b*). The lamp changer is so devised that in case of a lamp failure a magnetic contact allows a new lamp to be switched into focal posi-

tion. View (b) shows the normal operating position of the lamp at a, the filament being at the focal point with respect to the reflector; a spare lamp not in the position where it is operating is shown at b; a pivoted base on which sockets are mounted



(a) (b)

Fig. 22

is indicated at c; an electromagnet holding lamp a in its burning position as long as the lamp filament is intact appears at d; and a spring that pulls lamp b into focal position in case of the failure of lamp a is indicated at e. In addition to the main beacon, two 18-inch 500-watt *on-course* projectors are mounted on the tower below the beacon and pointed in each direction along the line of

flight. These are fitted with red cover glasses, and deliver approximately 17,000 candlepower, with a 10-degree vertical, and a 15-degree horizontal, spread. These colored lights flash the route identification in Morse code.

Intermediate landing fields are located about every 30 miles along the airways. On the beacon located at a landing field the *on-course* projectors are equipped with green instead of red to identify the location of the landing field. In addition, the landing field is provided with boundary lights, obstruction lights, approach lights, and an illuminated wind-direction indicator, or wind cone. All lights are kept burning from sunset to dawn.

38. Lighting Requirements for Airports.—The lighting requirements for airports, exclusive of the buildings, are divided into the following classes according to the equipment and function of each airport: (*a*) airport beacon; (*b*) illuminated wind-direction indicator; (*c*) boundary lights; (*d*) obstruction lights; (*e*) illuminated roof markings; (*f*) a ceiling projector; and (*g*) landing-field floodlight system.

The lighting facilities of an airport comprise one of the three major divisions upon which the granting of the Department of Commerce Rating Certificate is based. According to the Airport Rating Regulation, airports to obtain an *A* rating must meet certain minimum requirements in respect to each of the several classes of lighting mentioned. The general features of each class are here discussed briefly.

39. Airport Beacons.—Long-range all-angle visibility and position identification are the two major requirements for a satisfactory airport beacon. The rotating type of airway beacon is used most extensively for airports, although a fixed type with a flashing-light source is approved.

It is desirable to develop a beam of maximum candlepower from the standpoint of long-range visibility. At the same time, this beam must be of sufficient divergence so that, as the beam sweeps across the sky, the flash will be of such a duration as to permit the pilot to recognize it. This is a matter of allowing the light to fall on the eye for sufficient time for the eye to reach its maximum response. If a beacon were stopped in its rotation

with the beam turned directly toward an observer, the beacon would appear to become larger and more brilliant. The design of beacons is based on a compromise between high candlepower and the luminous period of the flash.

An airport beacon must be visible from all angles overhead from altitudes of from 500 to 2,000 feet. If a single light source is used, it is difficult to direct sufficient light to the upper angles without considerable sacrifice of the main-beam candlepower. In order to maintain an extremely high candlepower beam for long-range visibility, auxiliary projectors with medium-beam spreads and lower candlepower are sometimes used to provide visibility for the higher angles.

In order that an airport beacon may be identified from among the myriads of city lights, a requirement is that such a beacon incorporate a characteristic aviation-green flashing beam, of a minimum of 10,000 candlepower, visible in all angles above the horizontal plane. Unless the main beacon incorporates this green flashing identification, an auxiliary beacon must be provided for this purpose.

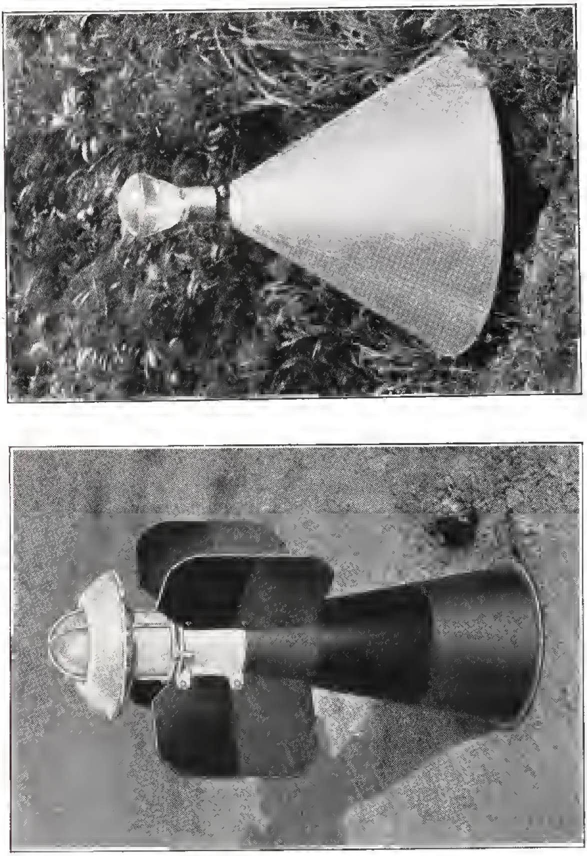
Automatic lamp changers must be provided in all airport beacons, or else a secondary emergency beacon must be provided which will be switched on automatically in case of lamp failure of the main beacon

40. Illuminated Wind-Direction Indicators.—At least one illuminated wind-direction indicator must be provided. The most common form is the *wind cone,* lighted externally by four 100- or 150-watt lamps in RLM, or bowl, reflectors with weatherproof fittings and mounted on short mast arms above the cone. Wind cones may also be internally lighted by a 200-watt lamp, and a reflector at the mouth of the cone.

Wind tees are frequently provided at airports for wind-direction indicators. They consist of a **T**-shaped form resembling a small airplane in appearance, so mounted on a vertical axis that it is free to move with the wind. These devices are preferably lighted by Neon tubes or incandescent lamps outlining the tee in green. Where lamps are used, 25-watt lamps in green-colored hoods and spaced not more than 12 inches apart are required.

For gaseous tubes, either 11- or 15- millimeter green tubing operating on 18 or 25 milliamperes is recommended.

41. Boundary Lights.—The entire area available for landing is indicated to the pilot by boundary lights spaced not more



(b)

(a)

Fig. 23

than 300 feet apart. Boundary lights should not exceed 3 feet in height, each light preferably provided with a skirt so that its position may be clearly visible in the daytime. Typical units are shown in Fig. 23 (*a*) and (*b*). Either plain or prismatic glass globes with weatherproof fittings are used and they must

be constructed and installed so that they are visible from all angles above the horizon. On series circuits, the sockets must be provided with film cutouts or an equivalent device for short-circuiting the socket in case of a lamp burnout.

Either clear or yellow globes are approved. Boundary lights with green globes are used at points offering the best direction of approach to the field. The distribution system may be either series or multiple, with suitable underground cable laid at a depth of at least 10 inches. Not less than 25-watt multiple lamps or 600-lumen series lamps shall be used for clear or yellow globes; for green globes, lamps of not less than the 50-watt or 1,000-lumen rating.

For series circuits no smaller than No. 10 A. W. G. conductors must be used. Where the operating voltages exceed 310 volts, a series transformer or safety coil must be installed at the base of each boundary light to prevent accident through high-tension current in the event of collision with the light. Some boundary lights are constructed with a receptacle contact in an outlet box set in the ground. These units, when knocked over, disconnect from the circuit and the exposed receptacle is short-circuited automatically. Individual transformers are not required with such units, nor in installations where the operating voltage does not exceed 310 volts or the maximum open-circuit voltage does not exceed 450 volts.

For multiple circuits, the size of conductor shall be such that the voltage drop does not exceed 5 per cent. of the normal operating voltage, and in no case shall the conductors be smaller than No. 10 A. W. G.

42. Obstruction Lights.—Red lights, either incandescent or Neon tubes, must be installed on all airport buildings and structures and on all towers, pole lines, and trees which are likely to prove hazardous for the aviator and plane. All obstruction lights should be placed on circuits separate from the other airport lighting. Obstruction lights for pole lines should be placed on each pole, with two lights, however, marking the end poles and the corner poles. For isolated obstructions, such as water tanks, chimneys, radio masts, and the like, two lamps should be used

at the top, with additional lights at one-third and at two-thirds of the way to the top. Not less than 50-watt lamps or their equivalent must be used for the red obstruction lights, and the more pronounced obstructions should have larger lamps.

43. Illuminated Roof Markings.—At least one hangar roof or other suitable area shall be marked with the name of the airport and the city or town. Such markings must be illuminated at night by outlining with exposed incandescent lamps or by gaseous tubes. When incandescent lamps are used, a minimum of 10-watt lamps, 8 inches apart for 6-foot letters, to 12 inches apart for 12-foot letters, is required.

44. Ceiling Projector.—Information as to the height of the clouds above an airport is of considerable importance to incoming pilots. Such measurements are made at night by projecting upwards, at a definite angle, a high-powered beam from an incandescent searchlight, preferably a 500- or 1,000-watt unit of less than 7-degree spread. When this beam of light is used in conjunction with a ceiling-height indicator, direct readings of the height of the clouds may be obtained. This indicator consists of a simple quadrant and a pointer set in the same plane as the projected beam and at a definite distance from the searchlight projector. By sighting along the pointer to the point where the projector beam strikes the cloud bank, and noting the resulting angle of the pointer, a direct reading of ceiling height is obtained.

45. Landing Area, Floodlight System.—The Airport Rating Regulations require that the entire usable portion of the landing area be floodlighted by one or more floodlight units, so that a uniform distribution of light, without abrupt changes in intensity or sharp shadows, is provided. The minimum illumination shall not be less than 0.15 foot-candle on the vertical plane at any point on the field. The units should be installed with sufficient flexibility and arranged to be controlled from a central point, so that landing is possible under all conditions of wind direction without the necessity of landing toward the light source.

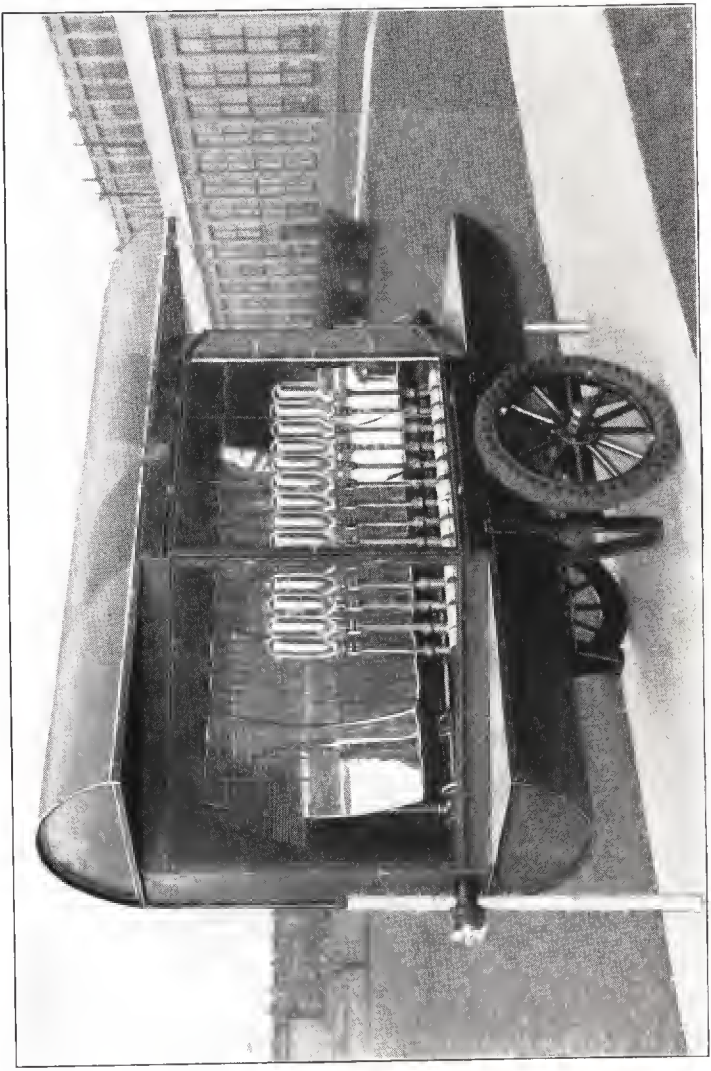


Fig. 24

The airport floodlighting requirements have occasioned the development of extraordinarily high-powered beams from single-unit floodlights or floodlight batteries. The projectors have been

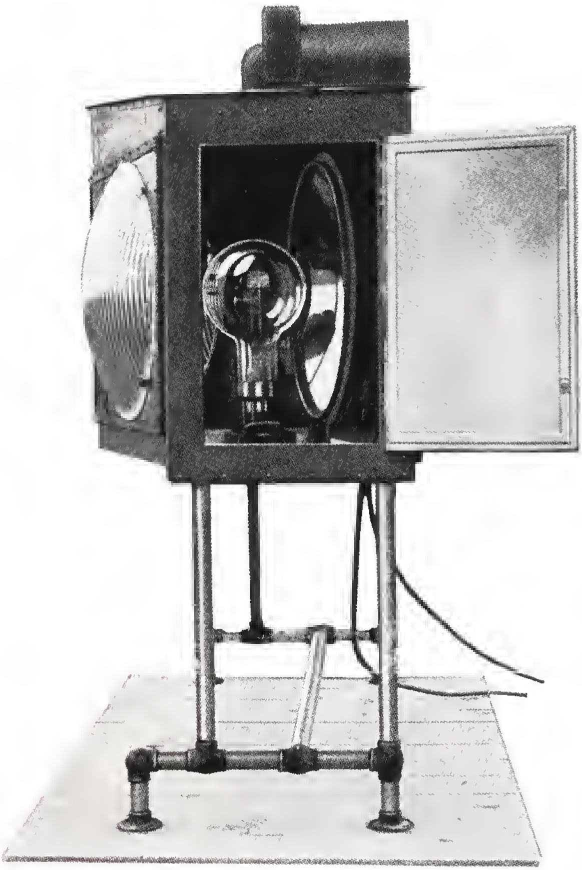


Fig. 25

designed to produce a flat blanket of light over the entire landing area. The beam is spread out by means of lenses and reflectors over a wide angle horizontally, but the vertical spread of the beam is sharply limited to a 5- or 10-degree divergence from the horizontal. The projectors are mounted only a short dis-

tance above the ground and the beam is aimed so that it does not rise appreciably above the horizontal plane.

Typical field floodlight equipments, employing one or more 1-kilowatt to 10-kilowatt lamps, are shown in Figs. 24, 25, 26, and 27. In Fig. 24 is shown a 24-kilowatt projector employing,

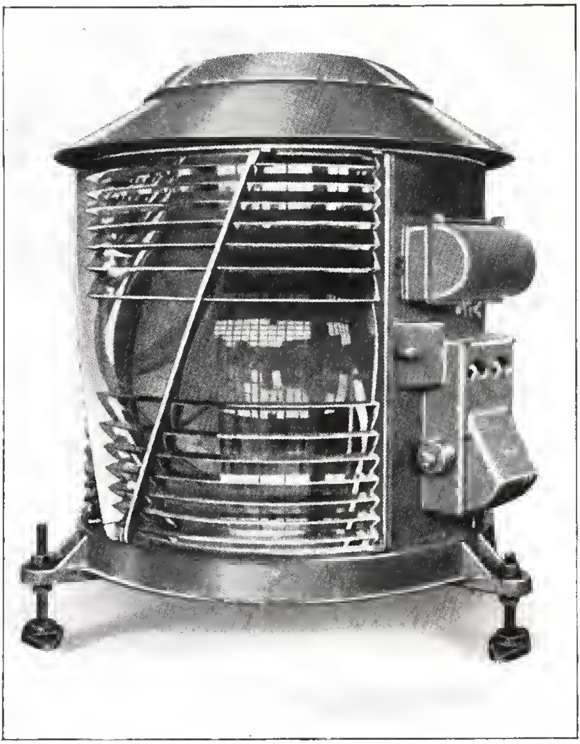


Fig. 26

as a rule, eight 3,000-watt or sixteen 1,500-watt lamps in a sectional trough reflector of parabolic contour. In Fig. 25 is shown a twin-lamp unit using two 5- or 10-kilowatt lamps with parabolic reflectors and horizontal, spreading lens. The mirrors shown in Fig. 25 are adjusted through holes in the back of the projector. In Fig. 26 is shown a large lens-type projector for a 150-ampere arc or 10-kilowatt incandescent lamp, while Fig. 27

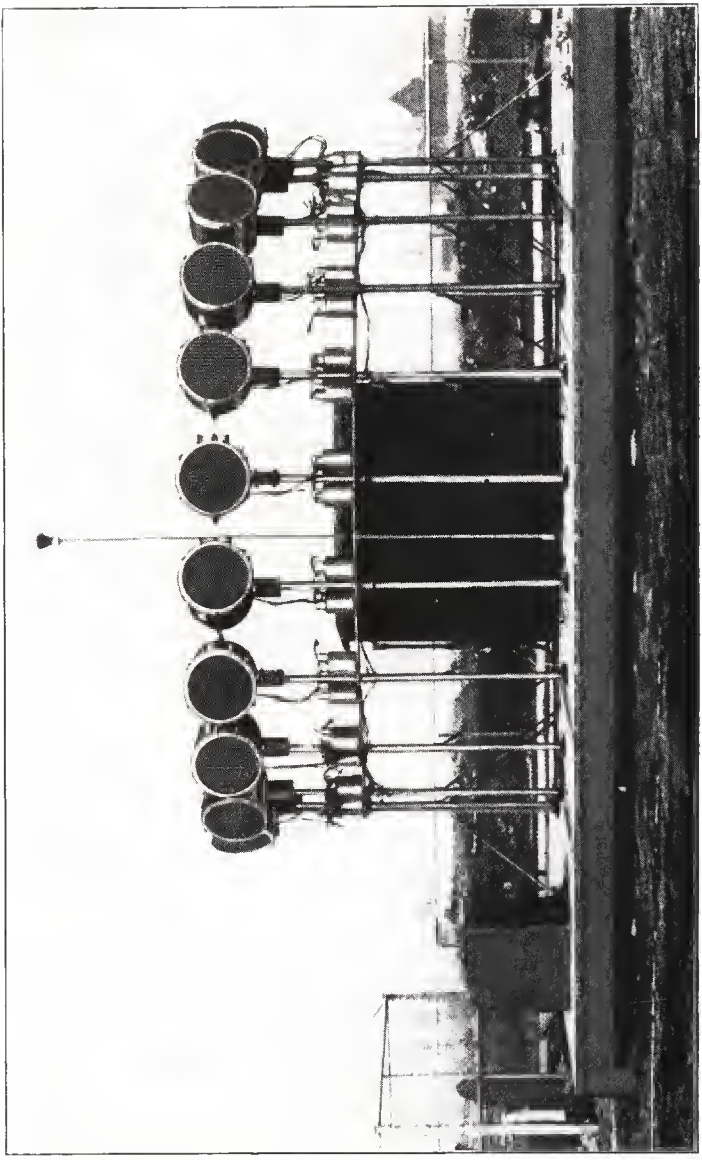


Fig. 27

shows a battery of single-unit projectors, each using a 1.5- or 3-kilowatt lamp.

46. Lighting Requirements for Landing Area.—Early airport floodlight systems consisted of a single high-powered projector of 20 to 30 kilowatts capacity, or at best several batteries of smaller projectors located at different points around the field. It is readily apparent that such systems are inadequate to provide uniform illumination of any appreciable intensity over the entire field, the area of which may range from four million to eight million square feet. Furthermore, it is difficult to avoid glare at times, even though the location for the units is chosen with regard for the prevailing wind direction.

In order that a pilot may not be required to land or take off directly toward a light source, it is necessary to install at least one, and preferably two, single high-powered light projectors or batteries of light projectors on each side of the field. A system of this kind allows the simultaneous use of two, three, or four units at the rear and right sides with several attendant advantages. These advantages are: first, the added wattage provides a higher standard of illumination, which is much needed; second, the lighting of any point on the field from several directions reduces the shadows; and third, the landing and the taking off would always be in the same directions as the projected beams, thus avoiding any necessity for the airplane pilot to face the light source.

A schematic wiring diagram for such an airport is shown in Fig. 28. It indicates the control for all lighting units brought to a central control panel at *a*. The power-supply lines are shown at *b*; the transformer room is at *c*, containing a power transformer *d* and a current transformer *e*; the field floodlight control is at *f*; the controls for the boundary, beacon, ceiling, obstruction, signal, cone, sign, loading, hangar, and parking light units are at *g*; and the 25 kilovolt-ampere remote controllers that control the various field floodlights are at *B*. A No. 8 single-conductor Parkway underground cable is indicated at *i*, and No. 6 two-conductor Parkway cables insulated to stand 2,500 volts at *j*. Field boundary lights are shown at *A*.

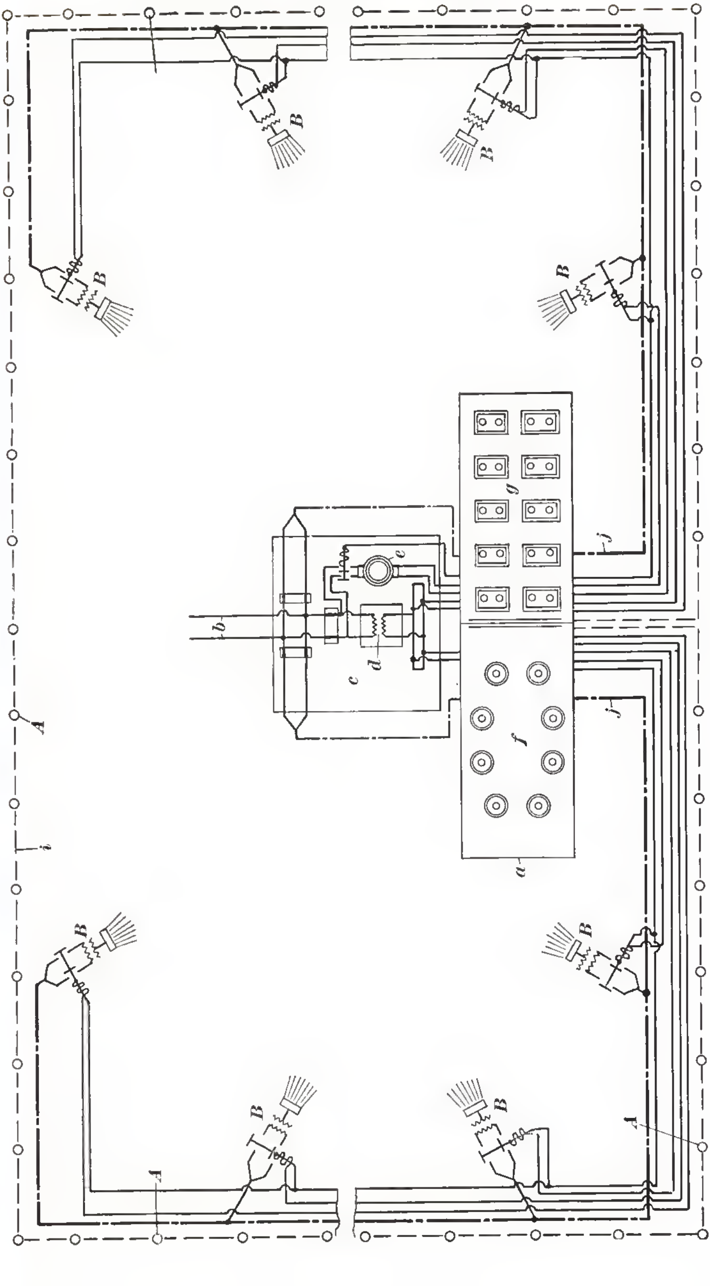


Fig. 28

ELECTRICAL ADVERTISING AND LUMINOUS DISPLAYS

47. General Discussion.—Electric signs in their early use attracted attention principally because of their novelty. Though somewhat crude and blatant in their appeal, nevertheless, they gained favor because of their effectiveness and attention value. Today they take their place as a definite medium in the general field of advertising. Because their use has extended so widely, the most effective design must be achieved in order that it will be noticed among the many that vie with one another for attention.

The field of electrical advertising and luminous display embraces a considerable range from the simple sidewalk signs using a few lamps or a single length of gaseous tubing, to huge spectacular displays with thousands of lamps requiring several hundred kilowatts of electricity. The introduction of gaseous conductor or Neon tubes has proved a great stimulus to the development of outdoor electrical advertising. Particularly effective displays have been worked out in combination Neon and incandescent lamps.

The field includes not only electric signs of many types, but also poster and bulletin-board lighting; festival lighting for amusement parks, street fairs, carnivals, and celebrations; and illuminated displays for holidays and Christmas. More recently, building displays for temporary use or in which luminous elements are built in and made a part of the architectural composition of the building have been added to the list already given.

48. Desirable Characteristics of Electric Signs.—A display, of whatever form, must have, first, attracting power, or the ability to gain attention; second, selling power, or the ability to impress its message and make it endure; third, legibility, or the property of showing wording or picture forms in well-defined, clean-cut lines.

Brightness and motion are two of the major characteristics of electrical advertising by which the designer obtains attracting and selling power. In no other form of advertising is there this opportunity to capitalize these most important attention-getting

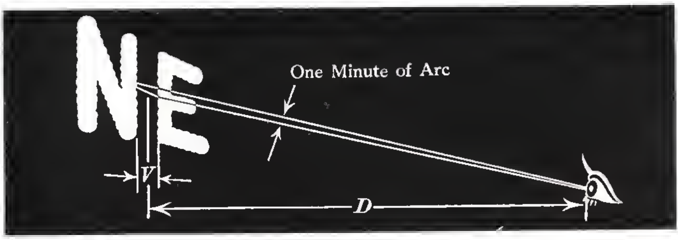
features. Originality, beauty, and color, like printed advertising, should be used to the fullest extent of ability and funds available. Other factors, such as decorative border, dominant size, position, and the use of pictures, can be compared for effectiveness in the same manner as they might be considered in newspaper- or magazine-advertising technique.

49. Factors Influencing Sign Design.—Complete data have been developed for predetermining the essential design features for effective signs installed under a wide variety of conditions. The procedure cannot be treated fully in this lesson and the reader is referred to the lesson *Wiring Finished Buildings* for practical tables (II to V inclusive) on lamp size, lamp spacing, and letter size. However, a brief discussion will be given of why accurate sign-design methods are necessary to insure, in a proposed display, the three following characteristics:

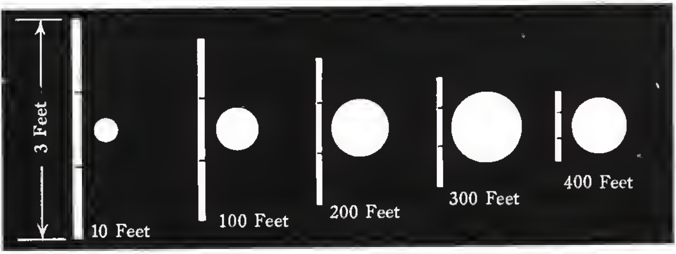
Brightness.—To compel attention, displays that are seen from great distances must be brighter than those seen from nearby. Similarly, displays in bright surroundings must be brighter than displays installed in darker locations, if they are to command their share of attention. It is highly desirable, therefore, to predetermine the desirable degree of brightness so that the sign may accommodate the proper lamp wattage.

Legibility.—Whether the message is carried by word or by picture, clear-cut, sharply defined lines of light are a prime requisite. No requirement in any form of advertising is more important than good legibility. Because of the longer viewing distances involved, careful design for legibility is particularly important in electrical advertising displays. In the usual sense, a pattern is legible if its component parts can be differentiated and identified. The required separation of the individual strokes of a letter or pattern depends upon two factors:

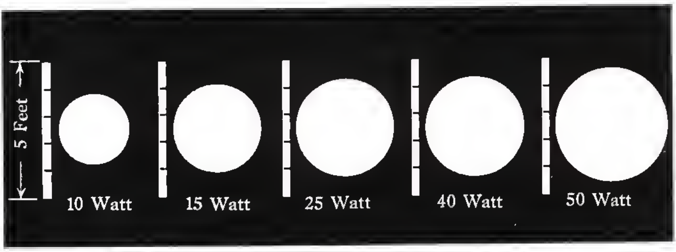
(*a*) The resolving power of the eye. The average human eye will distinguish two objects if the space separating them is great enough to subtend an angle at the eye of one minute of arc as illustrated in Fig. 29 (*a*) (equivalent to $3\frac{1}{2}$ inches at a distance of 1,000 feet). At any distance D, in feet, the necessary limiting separation V, in inches, is $V = 0.0035D$.


One Minute of Arc
V
D

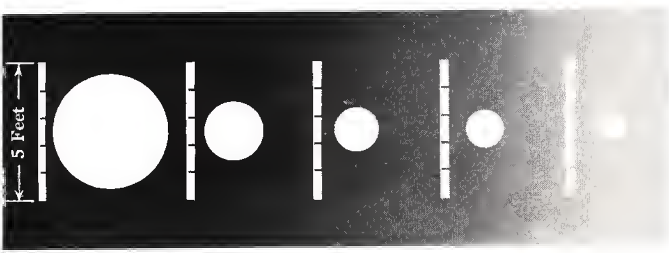
(a)


3 Feet
10 Feet
100 Feet
200 Feet
300 Feet
400 Feet

(b)


5 Feet
10 Watt
15 Watt
25 Watt
40 Watt
50 Watt

(c)


5 Feet

(d)

Fig. 29

(*b*) The contrast between the lines and their background. A luminous object appears larger than a non-luminous one, apparently increasing in size with the distance. An exposed lamp filament, when lighted, appears to swell; when viewed at close range against a dark background, it will appear perhaps one-third as large as the bulb. As the observer moves away, the spot of light will appear to expand until it fills the bulb, and will continue to grow larger and larger at greater distances. This effect, illustrated in Fig. 29 (*b*), is known as *irradiation*. The result of this factor is to increase the width of the strokes in a letter or a pattern, thus decreasing the separation between strokes and reducing the legibility distance at which the sign may be read. The irradiation effect varies and changes widely under different conditions. For example, the apparent size of a spot of light at a given distance increases if its brightness, that is, its wattage, is increased, as shown in Fig. 29 (*c*). As a counter effect, it appears to decrease in size as the surrounding brightness is increased, as indicated in Fig. 29 (*d*). The apparent size of a light source may, therefore, vary in diameter from a fraction of an inch to many inches, or even to several feet. It is also a fact that irradiation effect of light occurs, whether or not the lamps are enclosed in a channel.

It is obvious that the factors mentioned are important in influencing the spacing between lamps and the desirable wattage for any given brightness. It is interesting to note that a lighted border around a sign may oftentimes increase its legibility, by reducing the apparent spot size because of the greater surrounding brightness.

Smoothness.—A smooth lighted effect is the third object of accurate sign design. In the earlier days of exposed-lamp displays, lamps were distributed along the letter strokes for the purpose of lighting the background, the lamps themselves being comparatively inconspicuous owing to their low brightness. Today, however, lamps of many times the brightness of their predecessors are being used, with the result that the lamps are now the visible light pattern. This in itself has necessitated a complete change of point of view, and hence an entirely different design method must be used.

50. Since the apparent size of individual spots of light is smallest at the shortest viewing distance, it naturally follows that the closer the viewing of the display, the more closely must the sockets be spaced to produce a smooth, continuous line-of-light effect. Modern practice in socket spacing and wiring allowance for a closely viewed sign is given in Table VIII.

The statements that have just been made in discussing the three factors influencing sign design apply particularly to incandescent-lamp signs, since gaseous tubes inherently produce a

TABLE VIII

LAMP SIZES AND SPACING FOR SIGNS (CLOSELY VIEWED)

Lamp Wattage	Bulb Size*	Spacing Between Sockets Inches	Wiring Capacity Per Socket Watts
10	S-11	$1\frac{5}{8}$	10
10	S-14	$2\frac{3}{8}$	15
15	A-17	$2\frac{5}{8}$	25
25	A-19	$2\frac{3}{4}$	40
40	A-19	$2\frac{3}{4}$	50
50	A-21	$2\frac{7}{8}$	60
60	A-21	$3\frac{1}{8}$	75
75	A-23	$3\frac{1}{8}$	100
100	A-23	$3\frac{1}{4}$	100

*See lesson on *Electric Illuminants*.

continuous line of light. Neon tubes, however, do not usually allow the range in brightness obtained from lamp signs, although the same principles of irradiation apply as far as the distance and background brightness are concerned.

51. Enclosed-Lamp Signs.—Illuminated translucent letter signs do not have the brightness and sparkle of the exposed-lamp sign, but they have an advantage of a smooth, clear outline at close view, both by day and by night, and for that reason they are used largely for sidewalk signs. The appearance of signs of this type is greatly influenced by the lamp spacing behind the letters, the depth of the box, and the color of the interior. If the lamps are spaced too far apart the sign will appear spotty.

If they are placed too far inside the edge of the pattern, the outline will appear ragged and indistinct. A 6-inch spacing from lamp to lamp and a 3-inch spacing from lamp to projected edge of pattern will prove satisfactory in signs of ordinary construction, provided the surfaces are finished in white.

52. Importance of Beauty in Displays.—Fully as important as the mechanics of sign design are the factors which affect the beauty and artistry of the display. The sign which attracts but does not hold interest is low in advertising value, no matter how legible. It is through the intelligent use of color, logical and well-timed motion effects, proportion, grouping of lamps, and the control of brightness, that the designer is able to produce an outstanding electrical display which is effective as an advertising medium and which has the additional attribute of beauty. Displays of this type not only build good-will, but they go a long way toward eliminating the feeling that signs are inherently ugly and out of harmony in good surroundings. While it is a fact that hundreds of signs appear to clutter up our view along a street, this is due largely to the topsy-turvy-like growth of electrical advertising and to the lack of a well-planned development.

Electrical advertising and luminous displays need not be inappropriate to the location they occupy or ugly in the general appearance of the street as a whole. This matter is now being given consideration by architects in providing for exterior displays in original building plans, and by others interested in matters of civic beauty. This leads to a consideration of some of the facilities and features of modern installation of temporary and permanent luminous displays on building exteriors.

53. Temporary Displays.—There is a growing demand for elaborate decorations in light for public and commercial buildings on occasions of holidays, festivals, anniversaries, conventions or civic celebrations. Nothing is quite so attractive or fascinating as well-planned luminous decorations, but one deterrent to their wider use has been the trouble and expense incident to erecting and removing such displays. Many buildings offer

no facilities either for support or for convenient connection to electric outlets.

Some buildings are now incorporating well-anchored supports as illustrated in Fig. 30, which may be inconspicuously capped when not in use. Eyebolts *a* or stud bolts *b*, $\frac{1}{2}$ or $\frac{3}{4}$ inch in diameter, can be inserted at *c* when needed, and from them extremely heavy material can be supported safely. These supports should be of stainless steel to avoid corrosion and discoloration of the building. Such supports should be placed near the corners and also at intervals of 15 to 30 feet horizontally; vertically they should be located at nearly every floor and at the cornice.

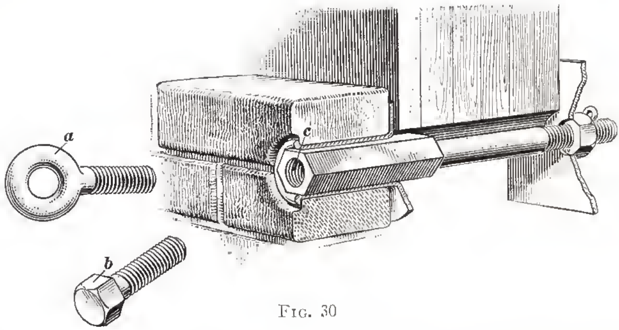


Fig. 30

Similarly, electrical outlets of marine or weatherproof type should be provided not more than 25 feet apart, horizontally and vertically, and preferably located under window sills. Outlets should also be provided on roofs, balconies, backs of columns, and above marquees. The wiring capacity should be sufficient for 2 to 10 watts per square foot of surface.

Such supports and outlet facilities on store and office buildings, theatres, hotels, and the like allow large advertising or spectacular displays of a temporary nature to be developed without prohibitive cost. Thus, stores may feature special anniversary sales, theatres may announce attractions, hotels may decorate for conventions, and for holidays and civic celebrations all may unite in a coordinated plan of decoration. The availability of decorative materials such as lighted medallions and installations with weatherproof sockets already wired at inter-

vals of 6 to 12 inches for festooning, has made outdoor decorative lighting more easily accomplished.

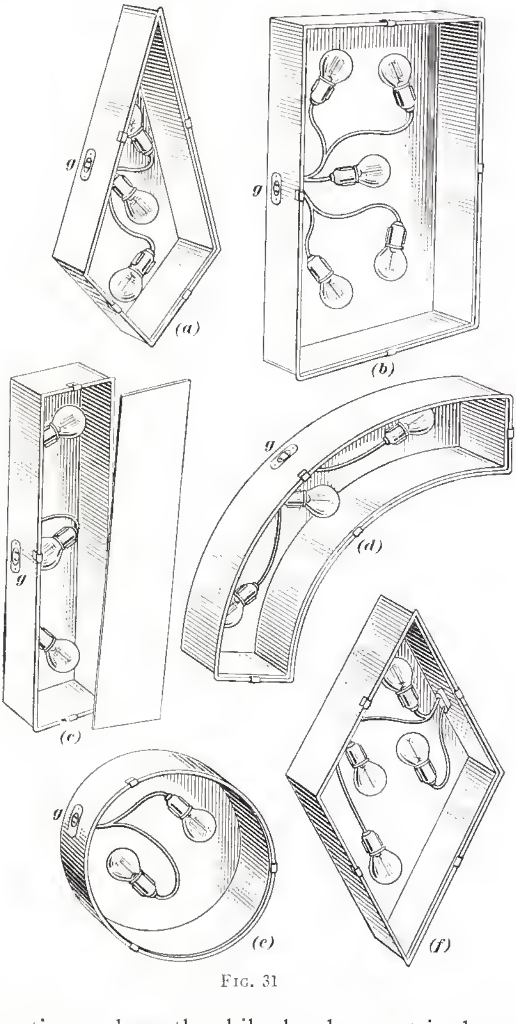


Fig. 31

An interesting and worth-while development in decorative elements is that of appliqué units. These units are made in several conventional shapes and can be used in all manner of com-

binations to work out an infinite variety of designs and patterns. They consist of shallow metal boxes with diffusing glass coverplates, which can be obtained in four or five colors; each box is wired for two to four sockets to take the small 10-watt, S-11 lamp. Each unit is fitted with a receptacle and a plug so that a series of units can be conveniently connected from one to another. Bolts with wing nuts on the back of the box make it possible to assemble the units very quickly on wire mesh to form any prearranged design. Different-shaped appliqué units are shown in Fig. 31. A spear head is indicated in view (*a*), a rec-

Fig. 32

tangle in (*b*), a bar in (*c*), an arc in (*d*), a circle in (*e*), and a diamond in (*f*). Flush receptacles for making connections to the lamps are shown at *g*. A night view of a small installation of appliqué units is shown in Fig. 32.

54. Permanent Displays for Buildings.—There is a definite trend in modern architecture to use luminous decorations as elements of architectural composition and adornment. Furthermore, recognition is more freely given to the fact that electric signs are almost a necessity to modern business. For that reason it is recommended that provision be made in the building design for signs to be built in and made a part of the general archi-

Fig. 33

tectural treatment. In this way, only, is it possible to have harmony in design of the building itself, and improved appearance of the street as a whole.

55. Provision for Signs.—Whenever a building is to have a series of retail shops on the ground floor or on the second floor, it is desirable to provide in the building wall above each of these a recess to accommodate a flat (fascia) sign. A good standard to follow is to allow for a sign with a depth of 8 inches, a height of from 1.5 to 3 feet, and a length, depending on the store width, of 15 feet or more. In such a recess, the tenant has opportunity to put an adequate sign without having it obtrude from the building in any undesirable way. Sufficient room is thus provided for a transformer for a Neon sign; or it serves equally well for an exposed-lamp sign, or for enclosed lamps behind translucent glass upon which letters may be silhouetted, or upon which pictures and ornaments in etched, molded or colored patterns may be introduced. Where no sign is desired, decorative patterns or decorative grilles in silhouettes may be used. This is illustrated in Fig. 33.

Similarly, provision should be made for the support of roof signs by extending vertical steel members above the roof, so that such signs may be erected at any time without extraordinary expense, as is so often necessary where no provision has been made for anchoring the heavy steel structural work of a large roof sign. The cost of providing facilities for a roof sign when the building is erected, whether or not a sign is contemplated, is but a fraction of the cost of making provisions for anchoring and for an electrical feeder conduit to take care of a sign later on.

Many of the newer commercial buildings, an example of which is shown in Fig. 34, incorporate large vertical and roof signs into the design of the building so as to be an integral part of it. A treatment of advertising signs in this manner is logical, presents good appearance both by day and by night, and is indicative of the possibilities for artistic and effective disposition of an element which has in the past more often than not detracted from the building architecture. Architects have only commenced to make provisions for such signs.


GATEWAY
Publix
Gateway
GALA OPENING FRIDAY JUNE 27 TH
SURPRISE PROGRAM - BIGGEST TALKING PICTURE

Fig. 34

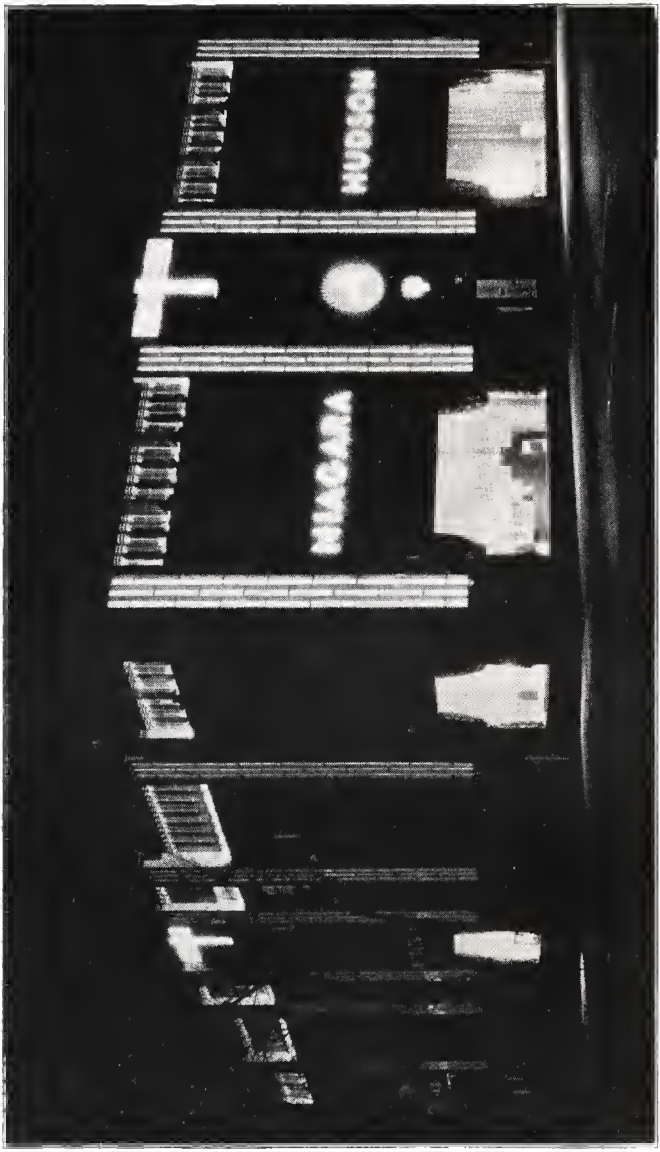


Fig. 35

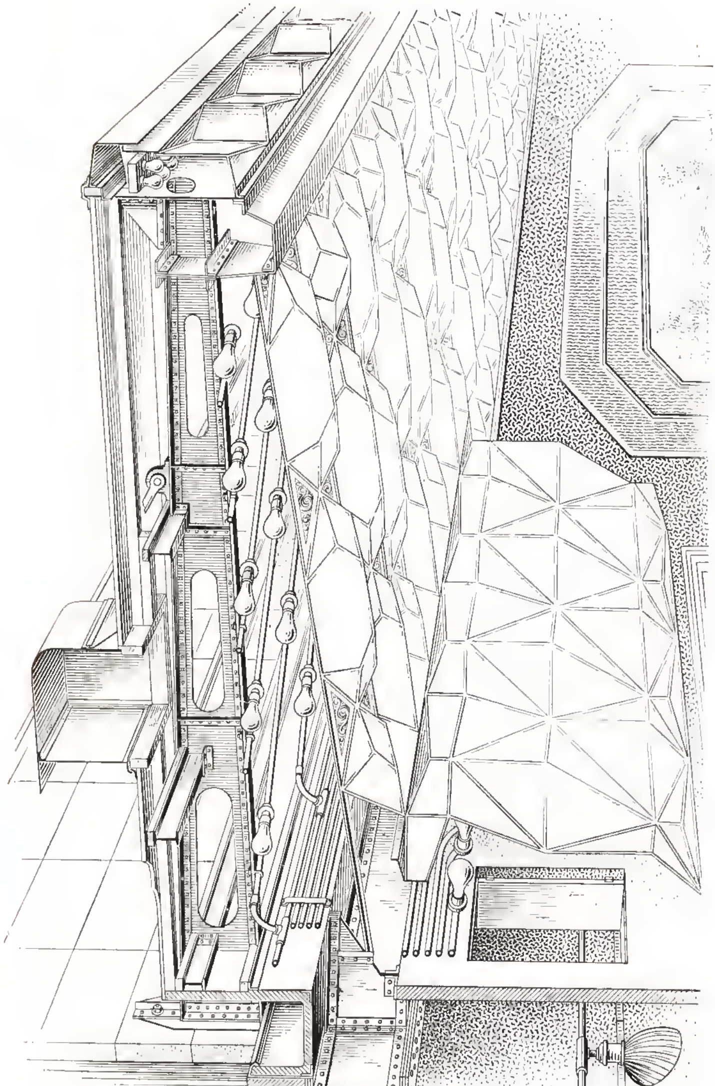


Fig. 36

56. Light as a Building Element.—In Europe the use of luminous elements as a part of the architectural treatment of building exteriors has developed much faster than in the United States; there are in the United States, however, a number of creditable examples sufficient to give direction to further development. Such buildings, of which Fig. 35 shows an actual example, offer a wide range of decorative possibilities. In Figs. 36 and 37 are illustrated methods for disposing of lamps and lighting equipment behind glassware, indicating how provisions may be included for lamp renewals and maintenance.

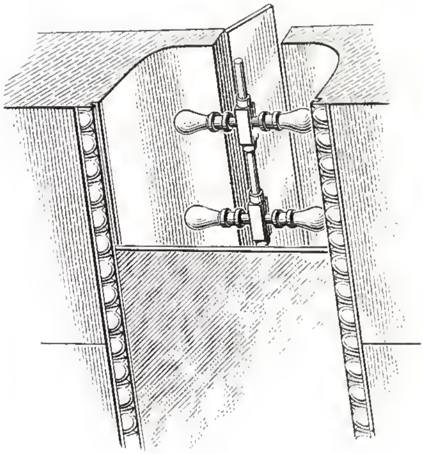


FIG. 37

The character and appearance of the translucent panels may cover a wide range. The glass itself may be of solid or flashed opal, configurated opalescent and crystal glass, molded, sanded or etched plates, ceramic colorings, leaded designs. Luminous panels lend themselves to extraordinary shadow effects, silhouette patterns, and infinite color tones.

For uniformly lighted panels of flashed opal glass, the cavity should be at least 6 inches deep with lamps spaced not more than one and one-half times the distance between the light source and the glass. Deeper cavities allow the use of larger, more efficient lamps at wider spacings. In estimating the lamp size or the

total lamp lumens required, the usual range is from 2 to 20 lumens per square inch of surface, depending on the kind of glass, the district brightness, the relative brightness of different elements, and the fineness of detail to be viewed in silhouette. Brightness shading, color shadows, and other interesting effects are worked out in the location of the lamps with respect to the panel.

The application of luminous elements offers considerable opportunity for those skilled in handling light in an artistic way. It is a new field requiring a full knowledge of lighting principles and technique and at the same time an equally good grasp of sound architectural practice. Columns and horizontal members, spandrels, parapets, and balconies offer especially favorable features for luminous treatment.

The many applications of outdoor lighting for utility and decoration cover such a wide range of possibilities, that the foregoing merely indicates certain features of modern practice and suggests what may be looked for in the way of future development.